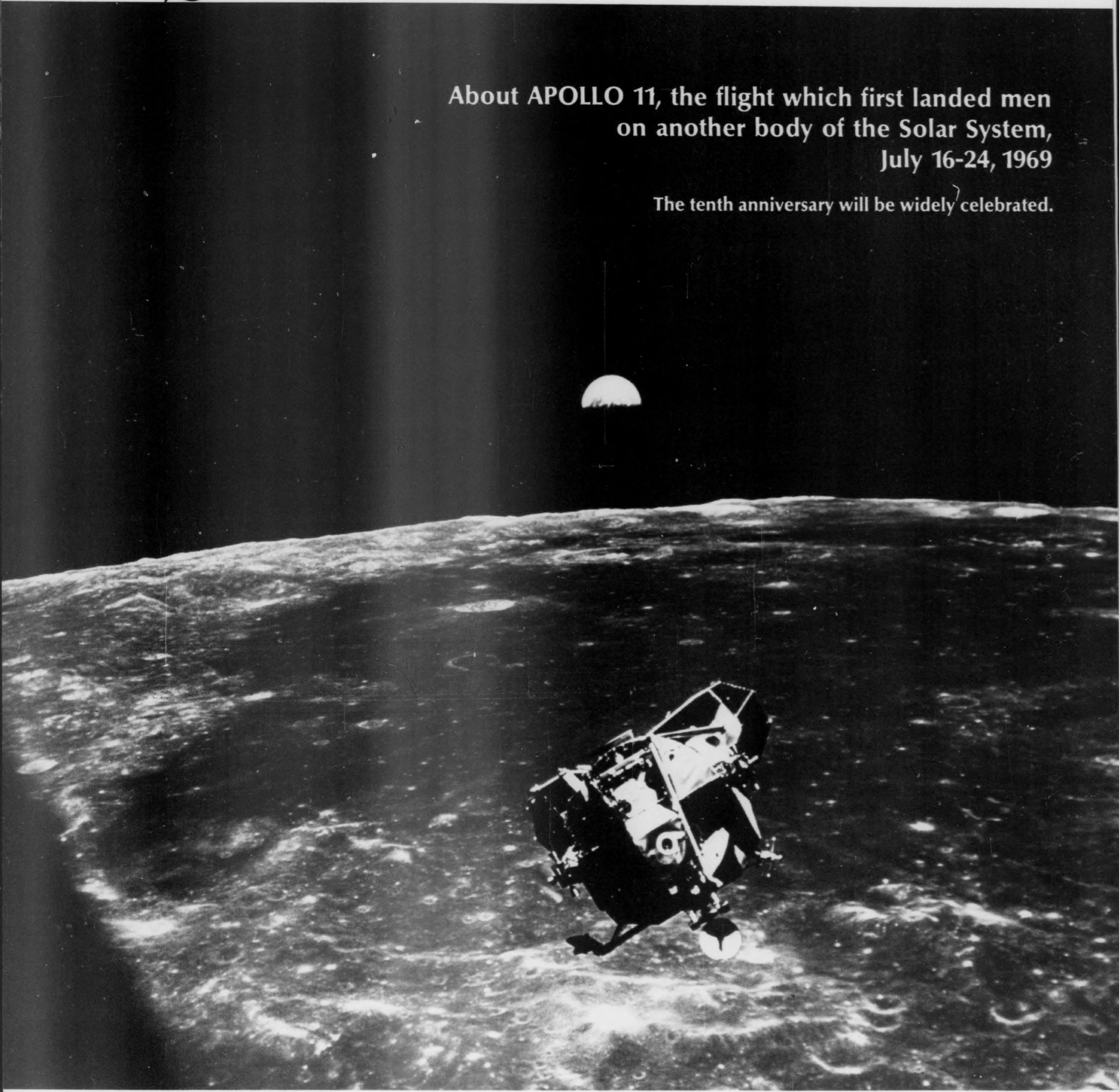
Air & Space

National Air & Space Museum
Smithsonian Institution

Vol. 2 No. 4 Mar.-Apr. 1979

About APOLLO 11, the flight which first landed men on another body of the Solar System, July 16-24, 1969

The tenth anniversary will be widely celebrated.



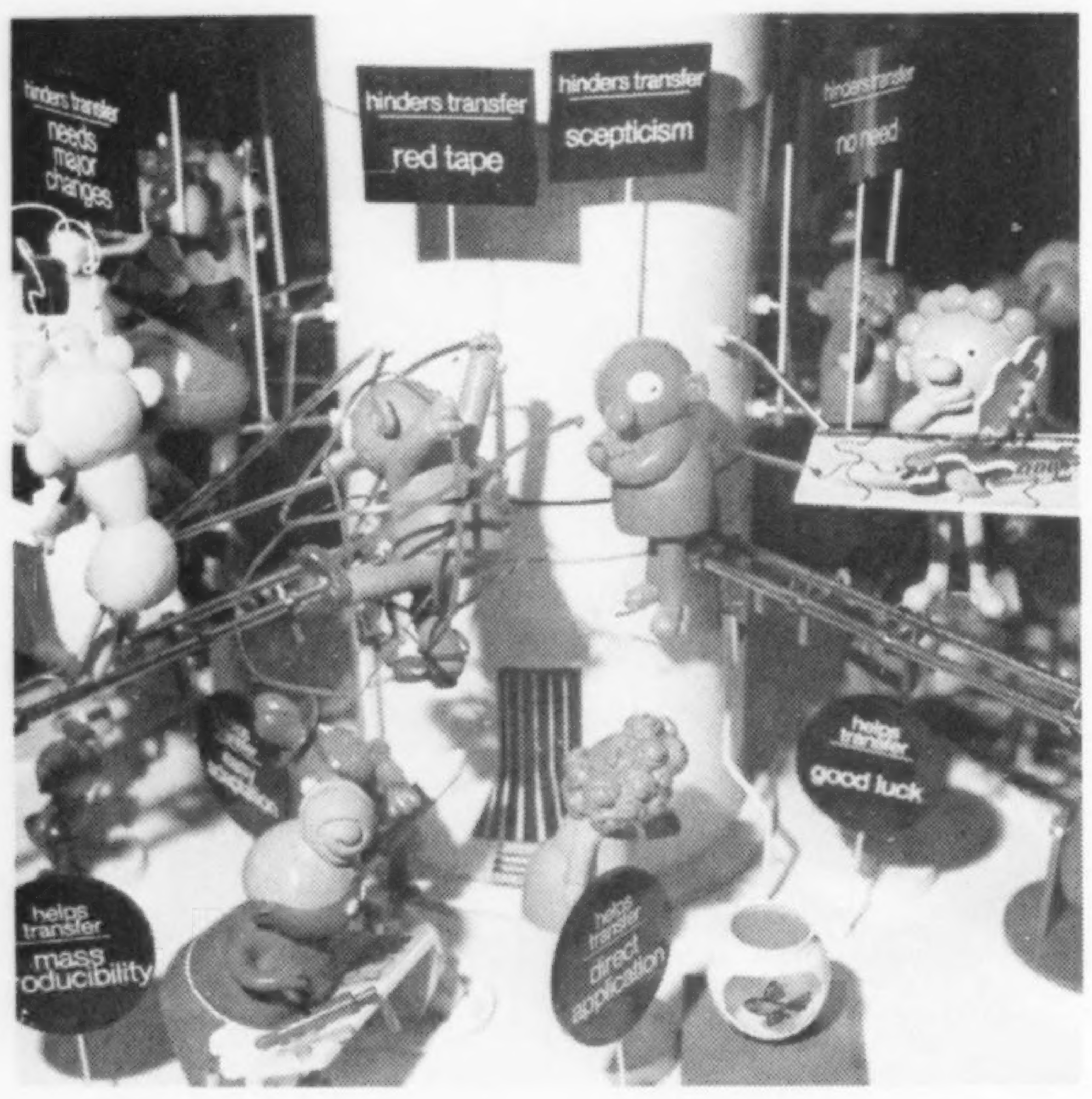
As the little globe of Earth rose above the lunar horizon, Michael Collins, in the Apollo 11 Command Service Module, photographed one of the happiest sights of his life, above. He had been orbiting the Moon while Neil Armstrong and "Buzz" Aldrin went down for their epoch-making demonstration that mankind can indeed survive and work elsewhere than on the home planet. Now they had successfully launched the ascent stage of their lander and were closing in for rendezvous, July 21, 1969. This was one of the final moments of agonizing suspense: What if something went wrong during docking and two or three men were stranded in lunar orbit? All went well, however. More on this mission, Pages 3, 4 and 5.

SCAN

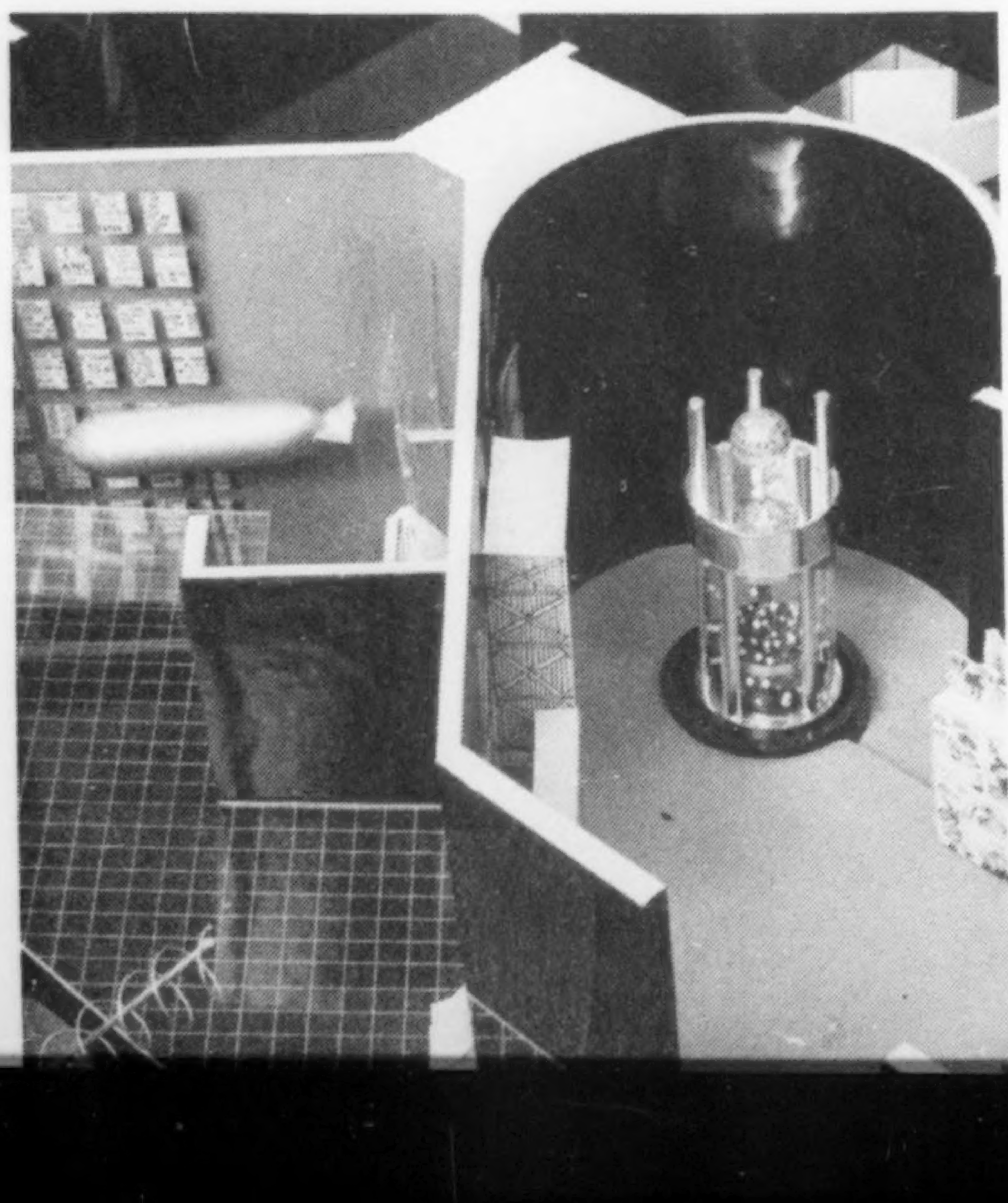
The story of Apollo 11 actually begins March 16, 1926. On that day, a mild-mannered professor, Robert H. Goddard, launched the first rocket ever powered by liquid propellants—liquid oxygen (colder than −297°F) and gasoline. The flight lasted two and a half seconds, reaching an estimated speed of 60 miles per hour and a height of 41 feet. The event is to the space industry as the Wright brothers' 1903 flight is to aviation.

With Smithsonian Institution help, Goddard did early work on solid fuels but came to realize that only liquids could provide enough thrust for space travel. He was the first rocket pioneer to go beyond theorizing and actually build, test and fly the first liquid propellant systems.

For brevity, the National Air and Space Museum is often referred to in these pages as NASM. The National Aeronautics and Space Administration is NASA.



Above: Detail of the NASM exhibit described in "Briefing." It is an ingenious dramatization of complex factors—reasons why new technology developed through funded research available to the public may or may not be adopted by other interests as "spinoffs." (More on this, Page 13.)
Below: Model which was made before installation of the gallery in which Mr. Zisfein's exhibit appears (in tall cylinder to the right).



Briefing

Melvin B. Zisfein
Acting Director, NASM

While planning an article on Exhibits Concept Development for a future issue of *Air & Space*, I came across one of those charming little dead ends that don't turn out as expected, but were great fun to conceive. About three years ago, I was in a plane en route from Chicago to Washington trying to hatch a design for a machine that would demonstrate the successes and frustrations (mostly frustrations) of transferring the high technology of flight to the problems of life here on earth.

My concept worked out and is on exhibit in our Museum. Ping-pong balls (representing ideas) are dispensed from a central booster-like shape onto four sets of rails radiating outward. The balls progress across the rails toward a rotating ring of "receivers," cartoon-like figures representing successful transfers of aerospace technology to areas such as transportation, medicine, public safety, etc. Moving in circular paths under the rails are benevolent little figures representing helpful factors such as "published data available," "transfer of skilled people," and "multiple uses." These advance the ping-pong balls toward their goals, the receivers. Moving in circular paths above the rails are malevolent little figures representing harmful factors such as "red tape," "skepticism," and "excessive complexity." These usually kick the balls off the rails, preventing the technology transfer.

The idea worked out beautifully and is now one of our feature attractions. However, conceiving this machine took only half of the flight. During the remainder, I began composing a label in doggerel. It got longer and longer, and when I finally completed it I decided that the Technology Transfer Machine was best served by a far briefer label. I'm no poet and for your amusement (perhaps pity is better) I now present some of the original long form so that members of our audience more gifted than I can write a good one.

**The transfer of technology
from air and space to you and me
is not an easy game.**

**The ships of flight require much,
like cermets, microchips, and such
too numerous to name.**

**Invented all to help us fly,
which clever things can we apply
there seems to be no dearth.**

**To transportation and to health,
can we apply flight's bounteous wealth
to improve life on Earth?**

**Does fire-fighting need flight's ways?
Can housing find a change that pays
from methods now in space?**

**Take management; here on Earth
can air and space enhance its worth,
and ancient ways replace?**

**What factors 'neath tech transfer lurk?
Must people change their place of work?
Or merely change their laws?**

**Must applications be direct?
Does blind luck ever help connect,
avoiding voids and flaws?**

**Must federal funding start a change?
Must education rearrange
our techniques of design?**

**Will ingrained ways prevent success?
Or can new techniques still progress
in ways we can't define?**

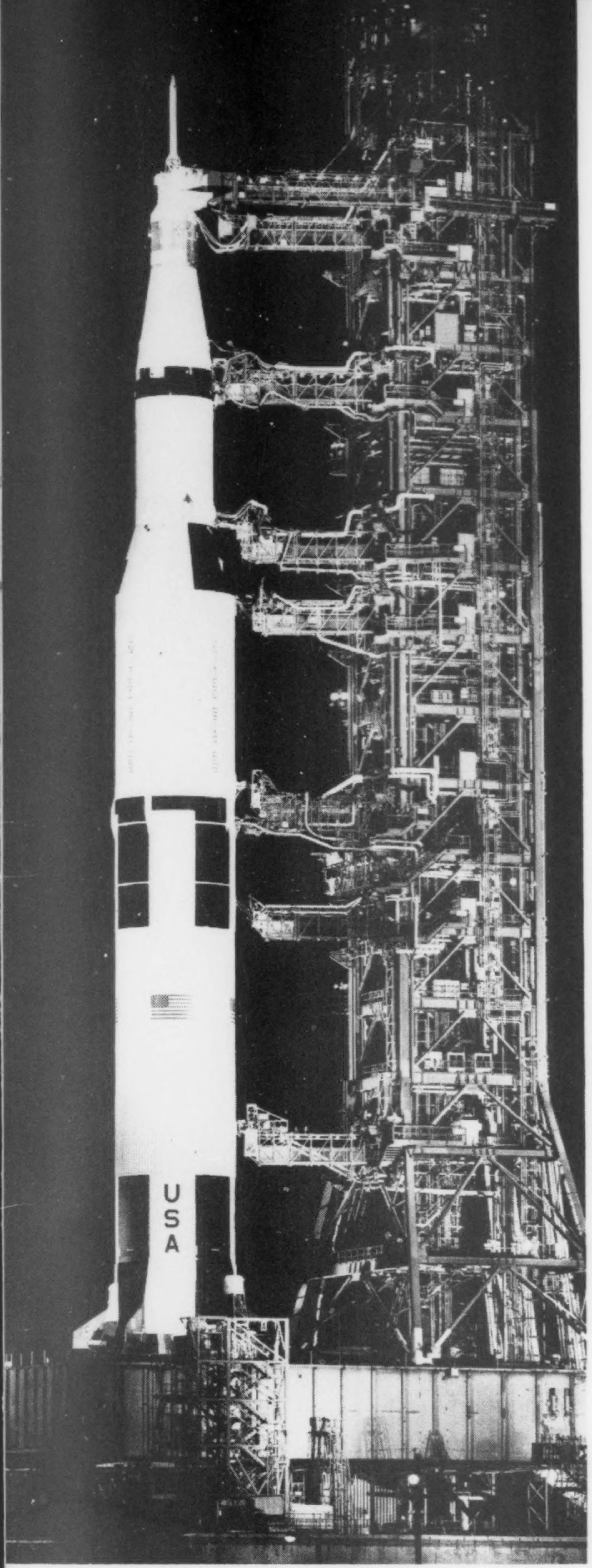
**What makes our transfers work sometimes
and sometimes not? Herewith these
rhymes to introduce a fancy:**

**A game with "Transfer Factors" strange
and "Users" who could use a change . . .
All moving balls, quite chancy.**

The poem goes on a bit but you get the idea. Oh well, at least the machine worked out well.

LEGACY OF THE U.S. MOON LANDINGS

New Capacities and Scope



Apollo 11 is the history-maker, the spaceflight which, for the first time, took men to the surface of another body in the Solar System. The astronauts' names are remembered. But Neil Armstrong, Michael Collins and Edwin E. ("Buzz") Aldrin, Jr. are always quick to pay tribute to the preceding manned flights. Each contributed something crucial to the final success which fulfilled the national commitment made by President John F. Kennedy in 1961—to land a man on the Moon by the end of the decade. And the later Apollo trips should be bracketed into any classroom study since the five additional landings brought a rich harvest of scientific data and operational experience. Students could each "adopt" one of the missions and report on specific advances made by the Mercury program, the Gemini series, Apollo 7, 8, 9, and 10, the famous 11, then 12, 14, 15, 16 and 17, and the near-disaster of Apollo 13.

Many publications offer the technical details. Here is an overview from ten years' perspective.

(1) During earlier flights, telecasts from space had fascinated viewers. But July 20, 1969 was something special. Communications satellites relayed news of the Moon landing by radio and television around this globe at the speed of light, in "real time." It is estimated that possibly half of all Earth's people shared the suspense of the breathtaking event on a "withered, sun-seared peach pit," as Michael Collins calls the Moon in his book (see next page). By contrast, the Earth underfoot looks like a pretty good place. Never before had one potent concept been shared by so many people simultaneously—the sense of Earth as only one globe in the void, and one deserving care. Let students list some new protective measures, and also some old human habits which could lead to serious planetary damage.

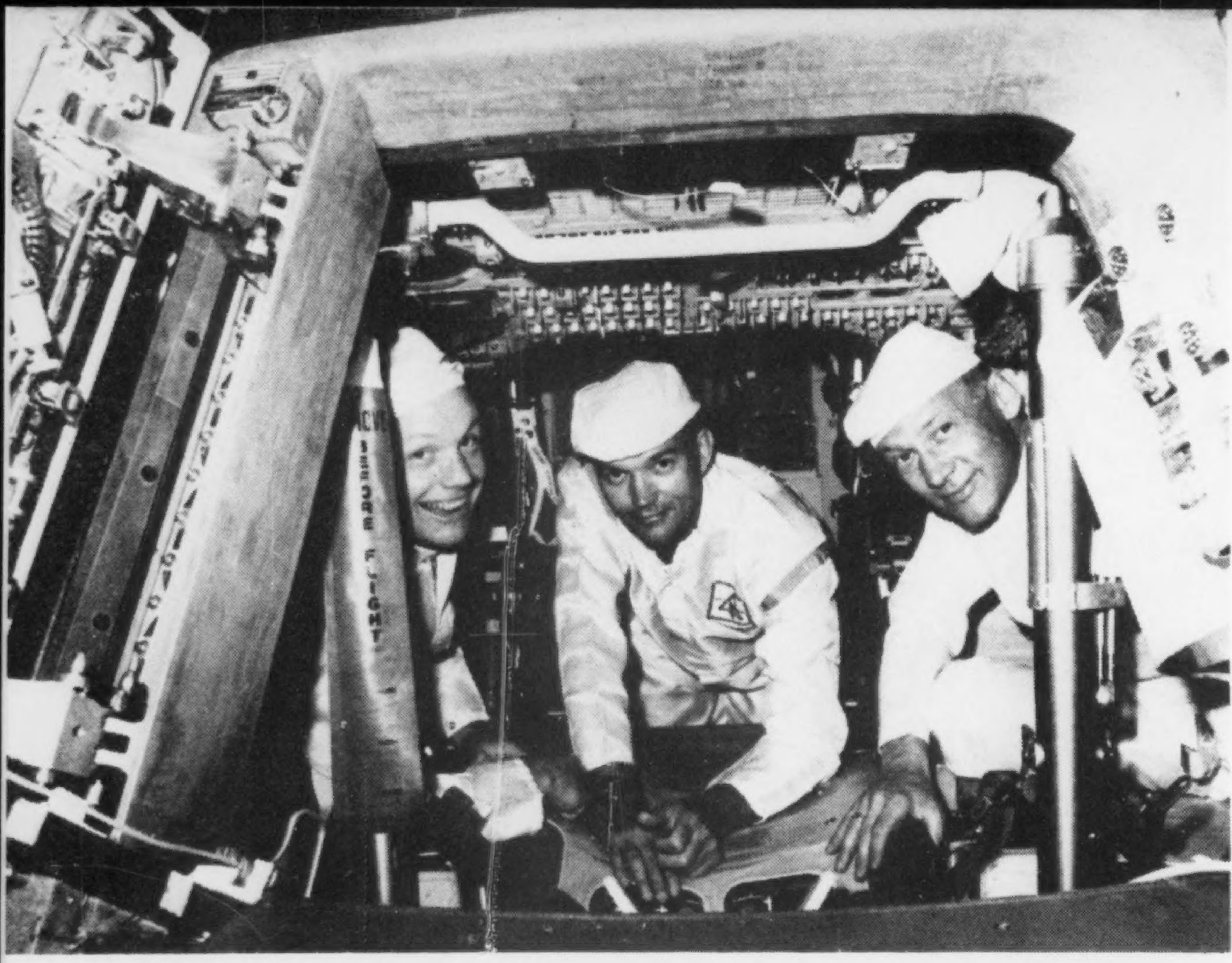
(2) Not only in one lucky voyage but in five more trips the U.S. put men on the Moon, and three times, a "dune buggy." Telecasts from the Moon, then from Apollo-Soyuz and Skylab dramatized the facts that the human species can be protected in a lethal environment and can work under strange conditions. Now even careful scientists make startling plans for mining the Moon, building huge structures in space, and drawing upon the solar energy which is so intense in space.

(3) To stay on President Kennedy's schedule, U.S. science and technology drove ahead with an intensity never before seen outside war. The unprecedented requirements were a "forcing function" in high technology, and also in systems of management for huge, complex enterprises. Federal advances in both areas are preserved in a computer storehouse, available to any inquirer. (See story, Page 13).

(4) Scientific data collected during the Apollo series are still yielding new insights into the history of the Solar System, and also into the particular values of the human observer versus automated instruments in space.

Left: A Saturn V on the launch pad is cradled by gantry arms which provide for fueling and for entry of astronauts into the Command Module, the cone near the top. The slender tip is part of a rocket system to blast the manned module free in case of trouble during launch. Using the most powerful cluster of engines ever built, the Saturn V climaxed the family of launch vehicles based on ballistic missile technology—expensive, expendable, never reused. (Large prints may be ordered at cost; see Credits, Page 6.)

Below: Apollo 11 countdown demonstration test in Firing Room No. 1, Launch Control Center, Kennedy Space Center, Florida. Some 450 people worked here during the Apollo lunar voyages.



Apollo 11: First-Hand Story

Excerpts from the book, Carrying the fire* *by the Apollo 11 Command Module Pilot, Michael Collins:*

When underway: "The moon doesn't appear to be getting much bigger but the earth is shrinking noticeably.... It is a sobering, almost melancholy, sight . . ."

"I remember last December, during the flight of Apollo 8, my five-year-old son had one . . . question: who was driving? Was it his friend Mr. Borman (Commander Frank Borman)? One night when it was quiet in Mission Control I relayed this . . . to the spacecraft, and Bill Anders promptly replied that no, not Borman, but Isaac Newton was driving. A truer description . . . is not possible. The sun is pulling us, the earth is pulling us, the moon is pulling us, just as Newton predicted they would. Our path bends from its initial direction and velocity after TLI in response to these three magnets."

After Armstrong and Aldrin enter the Lunar Module, separate from Collins' craft and go down for the historic landing, Collins remains in lunar orbit. He does not deny ". . . a feeling of solitude. It is there, reinforced by the fact that radio contact with the earth abruptly cuts off at the instant I disappear behind the moon. I feel this . . . as awareness, anticipation . . . almost exultation."

As Armstrong and Aldrin lift off the surface and approach for rendezvous (photo on the cover): "My hands are full with the arcane, almost black-magical manipulations called for. . ."

When all three are safely on the homeward course, "Houston pours out a potpourri of news and congratulatory messages (among them, one from) Mrs. Robert Goddard."

Excerpted from CARRYING THE FIRE by Michael Collins.

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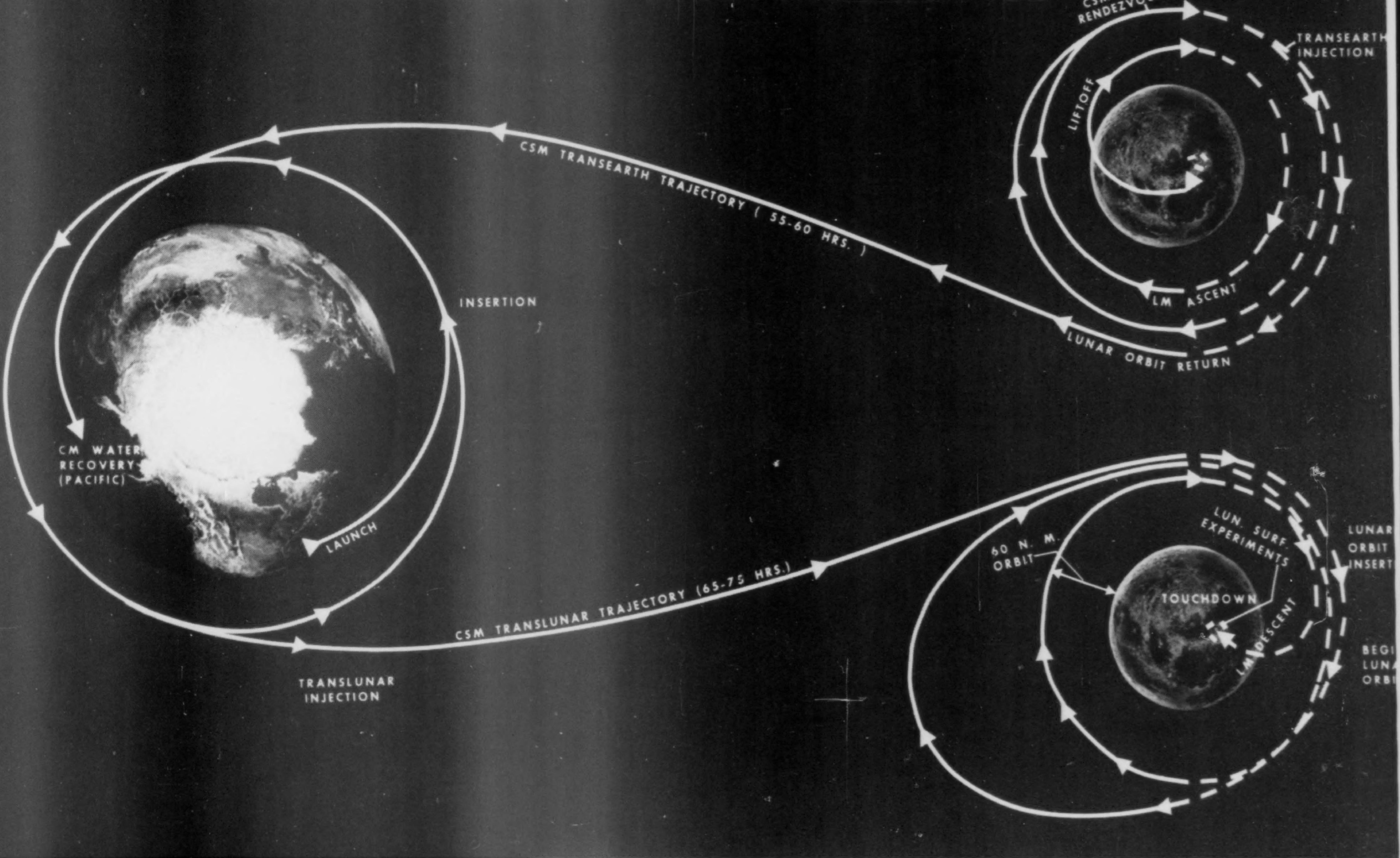
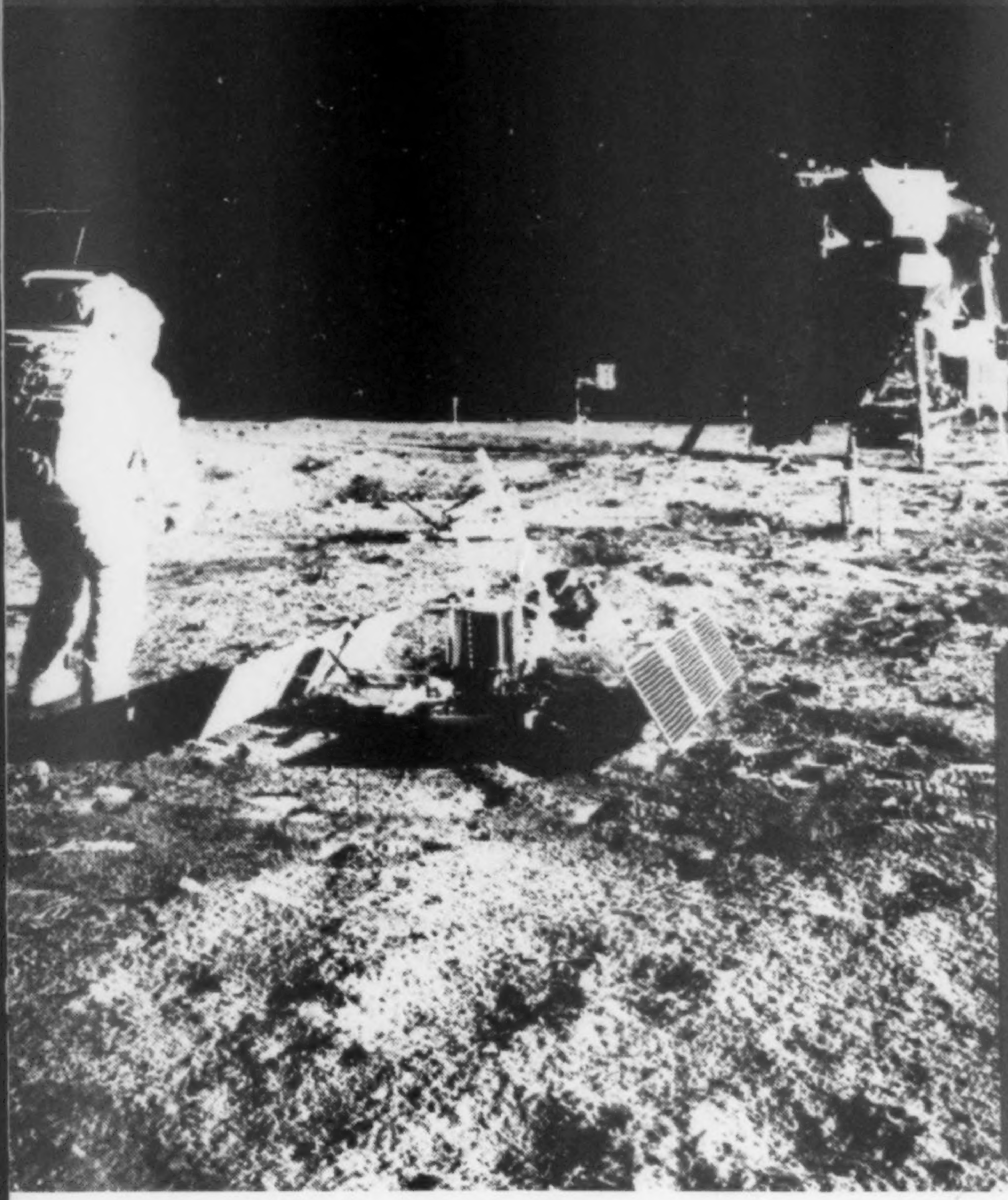
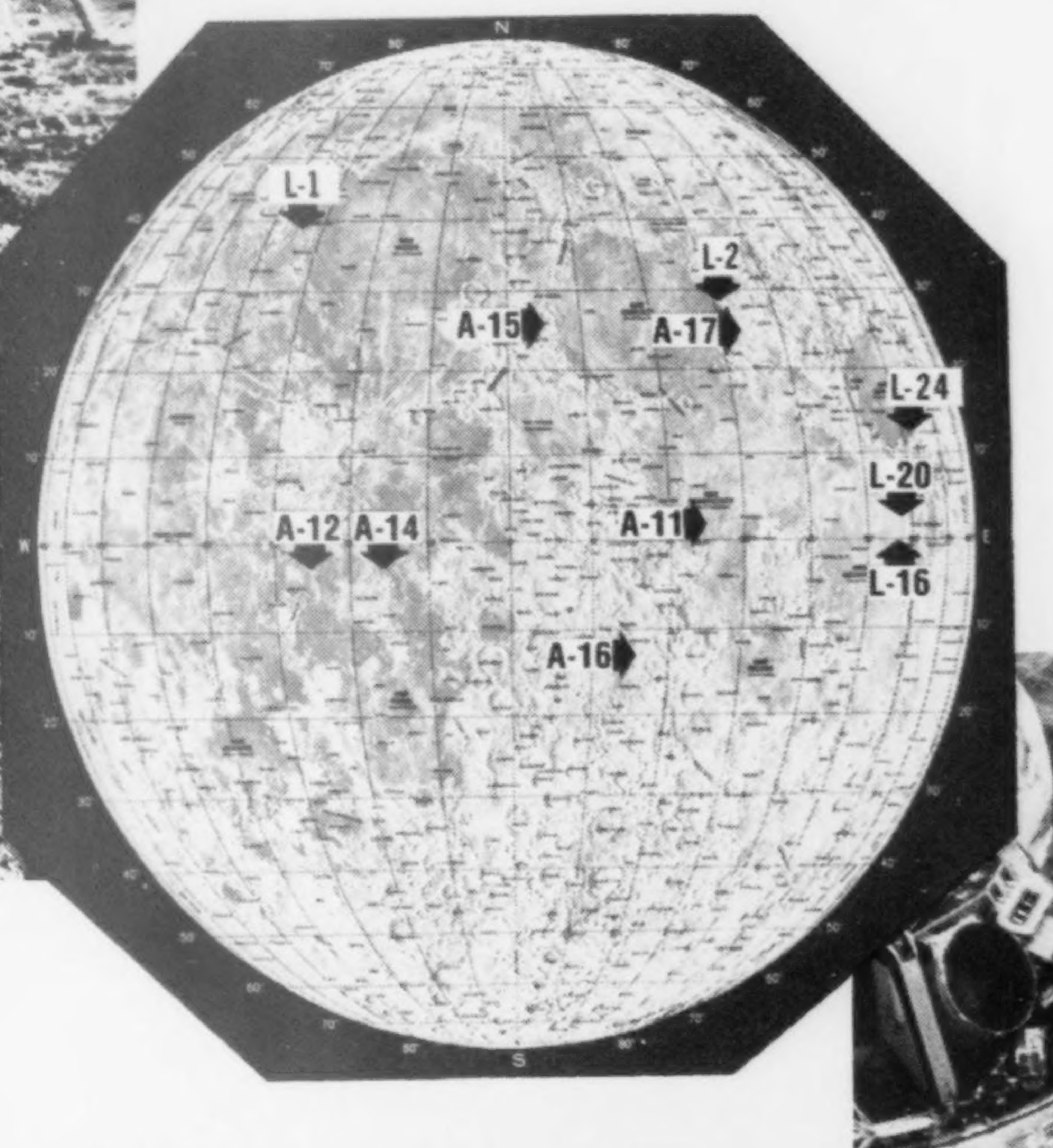
Top: In the Command Module, *Columbia*, L. to R., Neil Armstrong, Michael Collins and Edwin ("Buzz") Aldrin.
Above: Neil Armstrong in the Lunar Module simulator, and to the right, Mike Collins in the Command Module simulator. In his book, Collins writes that these simulators "were absolutely vital in preparing the crew . . . to master the intricacies of the very complex Apollo flights, which required split-second timing and perfect execution of hundreds of different tasks. . . . My greatest source of reassurance came from the simulator . . . between January and July I had accumulated 400 hours in it and it now felt like a comfortable home rather than a horror chamber."

APOLLO
LUNAR LANDING MISSION PROFILE


CSM-LM RENDEZVOUS
TRANSEARTH INJECTION
LIFTOFF
CSM TRANSEARTH TRAJECTORY (55-60 HRS.)
LM ASCENT
LUNAR ORBIT RETURN
INSERTION
CM WATER RECOVERY (PACIFIC)
LAUNCH
CSM TRANSLUNAR TRAJECTORY (65-75 HRS.)
TRANSLUNAR INJECTION
60 N. M. ORBIT
LUN. SURF. EXPERIMENTS
TOUCHDOWN
LM DESCENT
LUNAR ORBIT INSERT
BEGI LUNA ORBI

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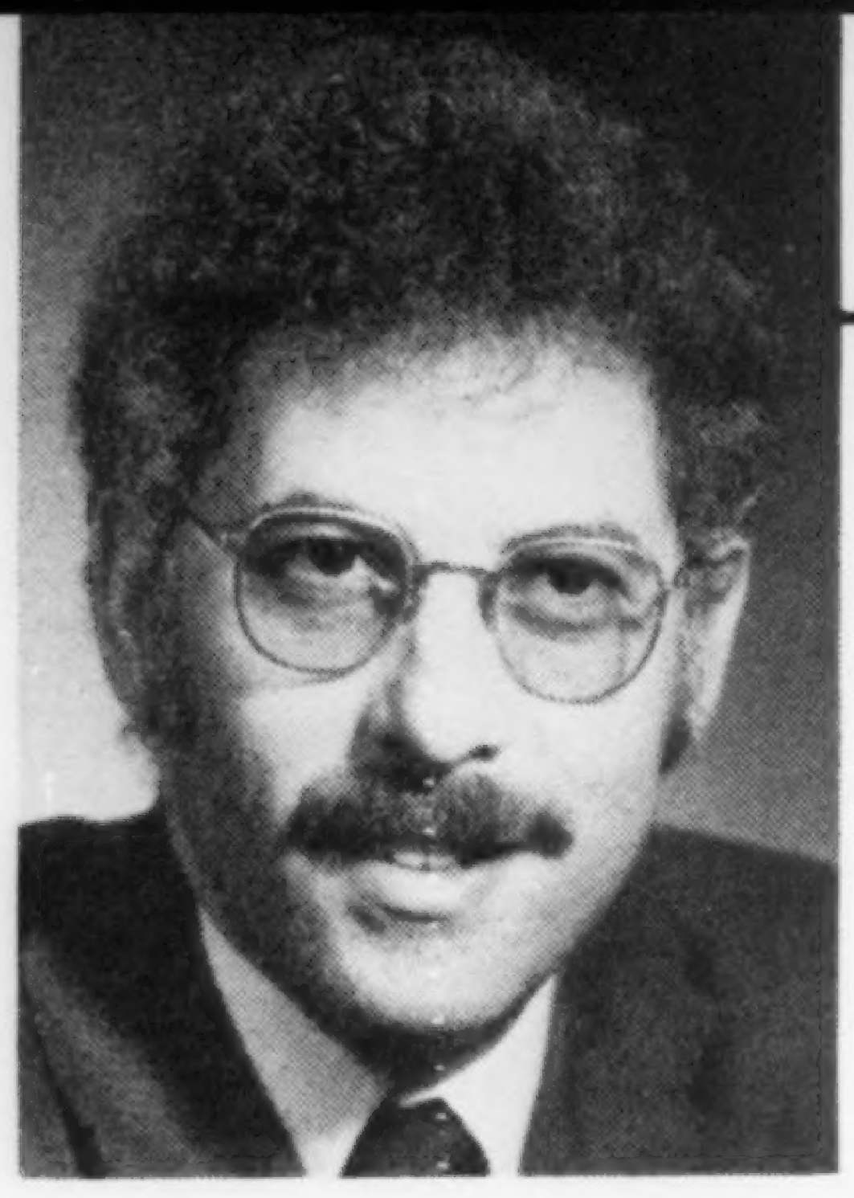
Above: Diagram of Apollo 11's round trip from Earth (North Pole view, at left) to the Earth-facing side of the Moon ("translunar trajectory") and home again ("transearth trajectory"). Abbreviations are: CM, Command Module; CSM, Command and Service Modules (the CM with the unit containing life-support and control machinery); LM, Lunar Module (two parts); N.M., "nautical mile," used in space as well as in ocean measurements; LUN.SURF., lunar surface.

Far left: "Buzz" Aldrin deploying scientific instruments (photograph by Neil Armstrong). A duplicate of the lunar lander in the background is on exhibit at NASM.

Left: Locations of all lunar landings. A = Apollo. L = Luna, the Soviet unmanned landings.

After splashdown, Apollo 11 astronauts donned "biological isolation garments" to prevent contamination of Earth by any lunar organisms. Procedure was abandoned for later missions since no organisms were ever found. Here, frogman disinfects area around hatch exit. This CM is on exhibit at NASM.



OUTREACH

by Kerry M. Joëls

Chief, Education Division

One of the gurus in the field of toy development and marketing once told me that the secret of a successful toy is one which children can relate to their everyday experiences. This is why such things as dolls and model cars are so successful. An important segment of toy sales relates to the child's aerospace experience.

We have all seen shelves stocked with *Star Trek* and *Star Wars* figurines (dolls) and spaceships (vehicles). The other side of the aerospace toy coin is, of course, airplanes. We have all seen helicopter rescue sets, model jumbo jets, inflatable airplanes, kites, balsa gliders, and the more ambitious airplane modeling kits. The toy airplane gives the child a direct stimulus to one of the most fascinating areas of human endeavor. We have to ask, though, how much is being done in the classrooms of America with this powerful motivational force? Since the market place is essentially proving in dollars that children relate to airplanes, shouldn't we as teachers examine what activities or fundamental concepts could best be taught using aviation?

Air transportation alone offers many opportunities for mathematical exercises, e.g., calculating passenger revenues, weights and measures, fuel consumption, etc. Word problems, a common mathematical bug-a-boo, can be constructed around experiences that children have in airports, e.g., the number of aircraft available versus the number of passengers.

Aviation touches many fundamental science concepts. The principles of flight are based on such fundamental notions as action-reaction, pressure, weight, shape, friction, speed and height. On the secondary level, physics, chemistry, human factors (biology), meteorology, even land use and pollution (particulate and noise) can be topics for lively lessons and discussions. Elementary science is a natural forum for learning about the physics and dimensions of flight. Many students lack a basic ability to comprehend spatial relationships such as distance, time, orientation, or speed.

Basic economics, geography and reading can draw on a variety of printed materials common to the general and commercial aviation community. History of famous aircraft and the use of aircraft in peace time and warfare make fascinating reading for students, and suggest simulation games for the operation of airports, runways, airlines or aircrew operations.

Even the "old faithful" activities of paper airplane contests and aircraft model building activities provide the child with hands-on psycho-motor experiences.

Aviation must not be seen as the domain of men. Women have not only made their mark, but in many cases lead the way. Women build airplanes, design airplanes, fly airplanes, and work in airplanes. In fact, various research and projects have shown aviation to be a motivating catalyst for activity with both boys and girls, and in schools of all socio-economic levels. High school classes have constructed experimental aircraft, and students with little or no hope for the job market have been stimulated to higher achievement by career possibilities in aviation.

If the toy stores aren't lying to us, children of all ages like airplanes. If they like airplanes, perhaps studying about them will help them learn. The movement in today's schools called "back to basics" still requires motivation of the learners, and aerospace activities can be a significant component in that motivation.

Astronauts' Words——Timely Sources——A $2.50 Textbook

Carrying the fire, an astronaut's journeys, Michael Collins, foreword by Charles Lindbergh; 478 pp., illus. Farrar, Straus and Giroux, New York 1974.

First on the Moon, a Voyage with Neil Armstrong, Michael Collins, Edwin E. Aldrin, Jr., written with Gene Farmer and Dora Jane Hamblin, epilogue by Arthur C. Clarke; 434 pp., illus. Little Brown & Co., Boston, 1970.

Return to Earth, Edwin E. ("Buzz") Aldrin, Jr. with Wayne Warga; 338 pp., illus. Random House, New York, 1973.

We Reach the Moon, John Noble Wilford, *New York Times;* paperback, 331 pp., illus. biblio., index. Bantam Books, New York, 1969.

The First Lunar Landing as Told by the Astronauts Armstrong, Aldrin and Collins in a Post-Flight Press Conference, paperback 9 by 12 in., 24 pp., 42 color illus. NASA, 1969, Government Printing Office, Washington, DC 20402, Stock No. 033-000-00162-2, $1.25.

Man in Flight, Biomedical Achievements in Aerospace by Eloise Engle and Arnold Lott, introduction by astronaut (now Senator) Harrison Schmitt. 400 pp., illus., biblio., index. The 50th anniversary commemorative volume from the Aerospace Medical Association, Washington National Airport, Washington, DC 20001. To May 1, $13.95 including postage; afterward, $16.95 including postage.

Directory of Aviation/Space, new biennial listing, hundreds of educational resources. American Society for Aerospace Education, 1750 Pennsylvania Ave. NW, Washington, DC 20006, first copy free to members, $2.95 to others. Lower prices for quantities.

Varying timely releases concerning their special interests are available from the Civil Aeronautics Board, 1825 Connecticut Ave. NW, Room 706, Washington, DC 20428; from the Aerospace Industries Association, 1725 DeSales St. NW, Washington, DC 20036; and from the General Aviation Manufacturers Association, 1025 Connecticut Ave. NW, Suite 517, Washington, DC 20036.

Your Aerospace World, National Headquarters, Civil Air Patrol; paperback, 8 by 10½ in., 231 pp., illus. Textbook at high school level; based on previous separate booklets. Book Store, CAP, Maxwell Air Force Base, Alabama 36112, $2.50.

ILLUSTRATION CREDITS

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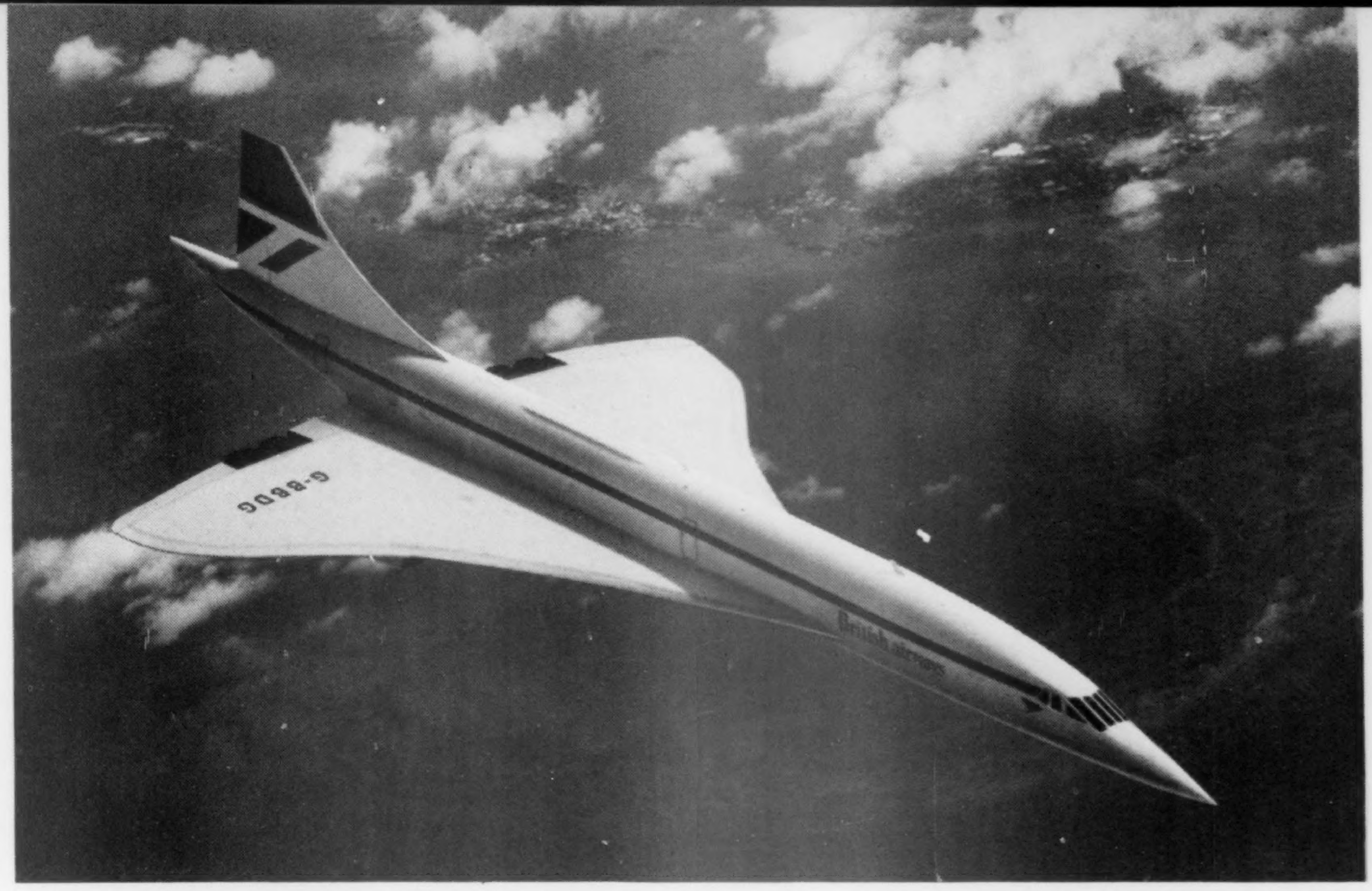


Left, the Concorde, built by both Great Britain and France to operate in two distinct aerodynamic regimes (sub- and supersonic) and at an enormous range of atmospheric temperatures. Average speed is often 2,100 kilometers per hour (1,300 mph). The Soviets are flying their Tu-144 supersonic transport (SST). The U.S. cancelled its SST for economic and environmental reasons. Military supersonic aircraft have been flying throughout the world regularly since the mid-1950s, with little detectable impact upon the environment.

From the Sound Barrier to Space

by Richard P. Hallion
Curator, Science and Technology, NASM

Since 1945, the major thrust in aeronautics has been towards supersonic and hypersonic flight. Supersonic flight involves flying at speeds above that of sound (Mach 1: 1,223 kilometers per hour, or 760 mph, at sea level). Hypersonic flight involves flying at velocities faster than five times that of sound (Mach 5).

The first flight faster than sound occurred on October 14, 1947, when Capt. Charles E. Yeager reached Mach 1.06 while flying the experimental Bell XS-1 rocket research airplane. The XS-1 (later known as the X-1) is now suspended in the Milestones of Flight Gallery at NASM.

In 1953, Mach 2 was exceeded for the first time. With the frontier of Mach 2 flight mapped out, scientists and engineers embarked on a series of design studies for supersonic military and commercial aircraft. So far, only one regularly scheduled commercial supersonic aircraft has been developed: the Anglo-French Concorde supersonic transport (SST). Britain and France began development work on supersonic airliner design starting in 1956, and in November 1962, the British and French governments signed a joint agreement for the design, development and production of a supersonic airliner. Such a craft must fly at subsonic speeds, transonic speeds (the zone just below and above Mach 1) and at supersonic speeds.

To avoid aerodynamic heating problems, the design teams opted to build just a Mach 2 airplane . . . any faster, and the craft could not have used aluminum as its primary structure. The firms also selected a low-aspect-ratio (slender) delta configuration. The first Concorde was completed in France in 1968, and made its first flight on March 2, 1969. On October 1, 1969 it made its first supersonic flight, and made its first Mach 2 flight over a year later, on November 4, 1970. Production Concordes subsequently entered service with Air France and with British Airways, flying to the Middle East and to North and South America.

Hypersonic Flight

The X-15 series built by North American Aviation (now Rockwell International) pioneered hypersonic flight. Three X-15s were built; the first one is now on exhibit at NASM.

Powered by a liquid-fuel rocket engine burning a mixture of liquid oxygen and anhydrous ammonia, the X-15 series was capable of flight at Mach 6, where surface temperatures often rose above 1,200°F. The X-15 series were carried to high altitude by a modified Boeing B-52 launch aircraft before being dropped. The X-15 pilot would then ignite the rocket engine, and the sleek black plane would quickly accelerate to high speeds and high altitudes. After rocket burnout, the pilot would then guide the aircraft back to a landing on the hard clay surface of Rogers Dry Lake, California.

The three X-15s were used for aerodynamic research on the problems of atmospheric reentry at hypersonic speeds. Because they operated on the fringes of space, often exceeding 80 kilometers altitude (one reached 108 kilometers), they required both conventional control surfaces for flight within the atmosphere, and special rocket "thruster" controls for maintaining attitude control in space. Aspects of the X-15's design and equipment influenced such subsequent ventures as the Mercury spacecraft and the Space Shuttle orbiters.

Space Flight

A more ambitious step beyond the X-15 is the Space Shuttle, which represents a design and development partnership of NASA, other federal agencies, and many industrial concerns.

(Picture story of system operations in the November-December issue of *Air & Space;* closeups of the second orbiter, Pages 10, 11 and 12, this issue.)

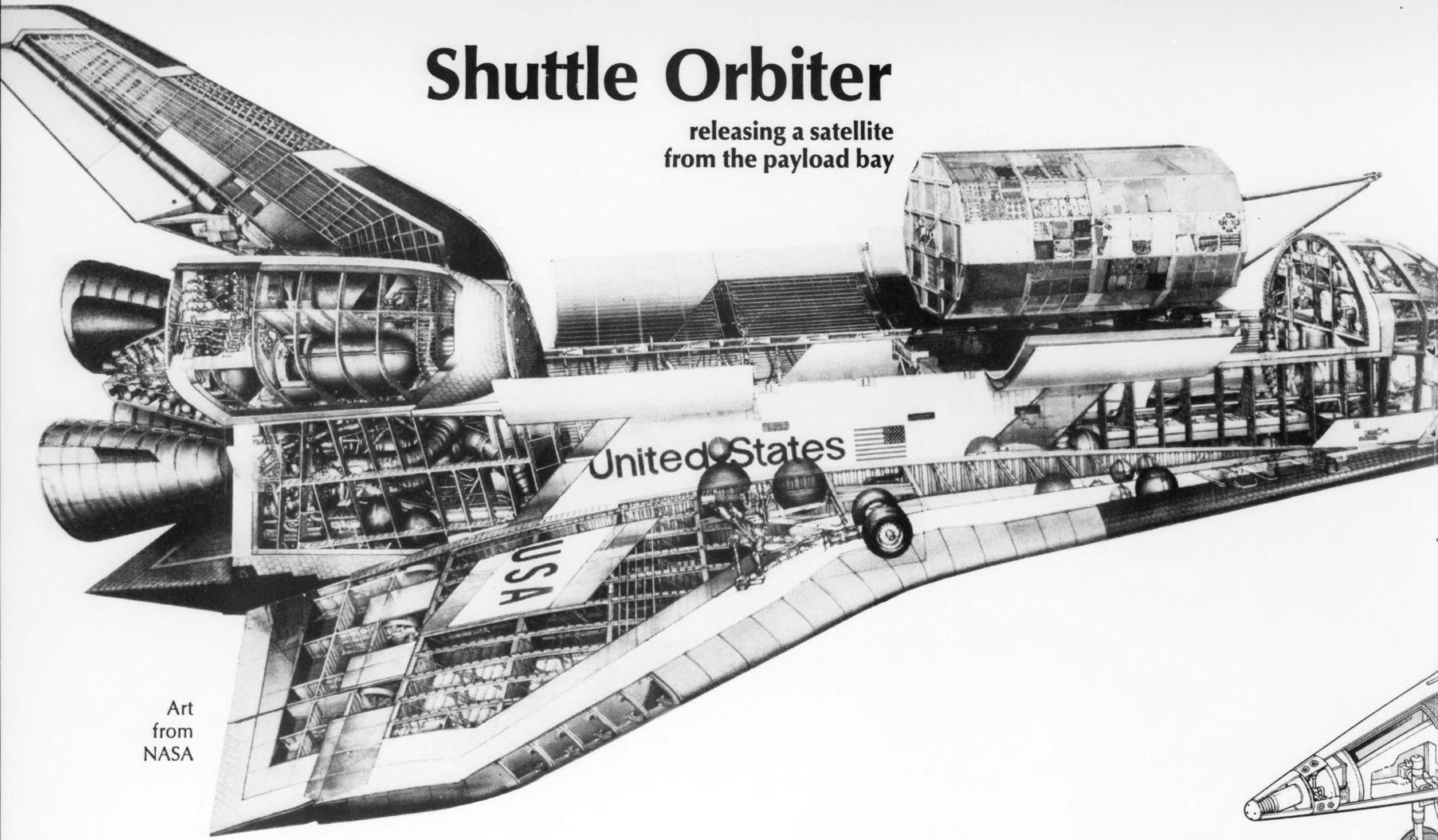
The orbiters, unlike earlier space ventures, will return to Earth with aerodynamic controls, reentering the atmosphere at about Mach 25, gliding hypersonically to lower altitudes, decelerating to supersonic speeds, and then landing like a large glider.

In 1977, NASA completed low-speed landing tests of the Orbiter Enterprise (OV-101, for "orbiter vehicle 101"). This orbiter was carried aloft on the back of a 747 jet transport and released for a series of short glides back to Rogers Dry Lake, criss-crossed with natural "runways" at the NASA Hugh L. Dryden Flight Research Center, California.

Orbiter OV-102 should roar into orbit from Kennedy Space Center later this year, marking a new phase to the utilization of space. Its first orbital flights will land on Rogers Dry Lake, which is nearly 13 kilometers long (8 mi). Subsequent flights will land at Kennedy Space Center, Florida, or at Vandenberg Air Force Base, California. These runways are identical, 4.57 kilometers long (2.84 mi).

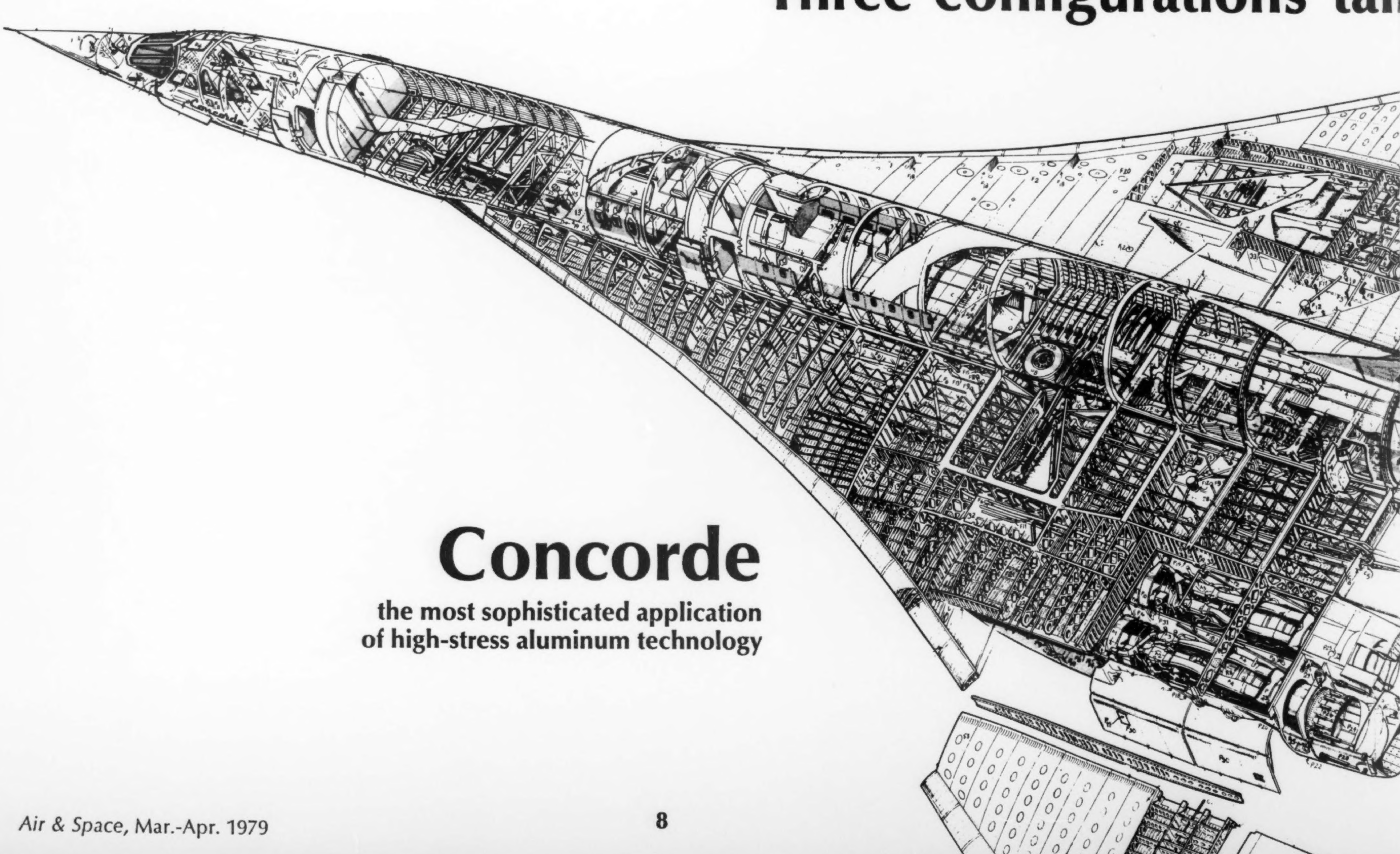
Shuttle Orbiter

releasing a satellite
from the payload bay


United States
NASA

Art
from
NASA

Three configurations tail

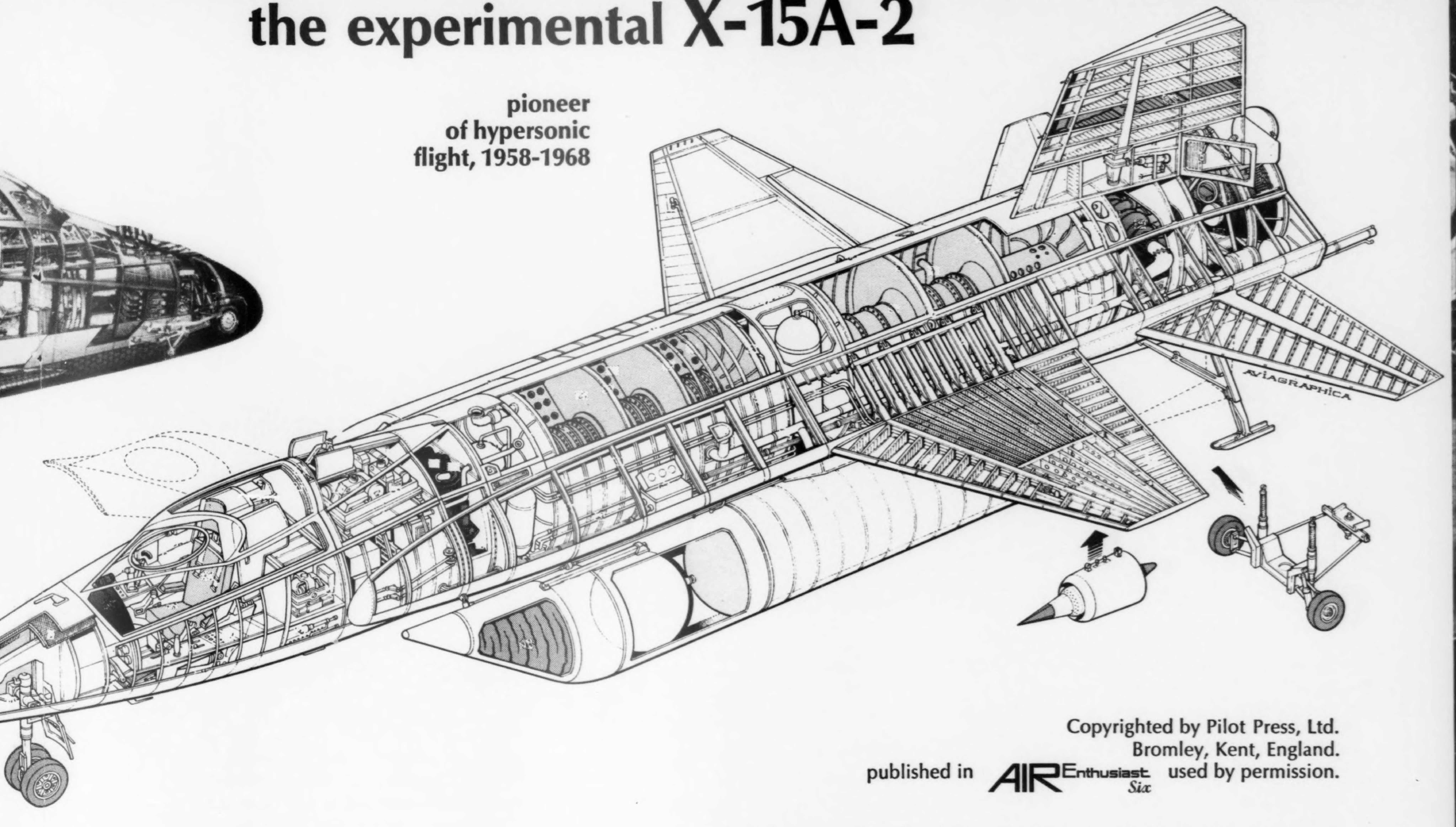


Concorde

the most sophisticated application
of high-stress aluminum technology

the experimental X-15A-2

pioneer
of hypersonic
flight, 1958-1968



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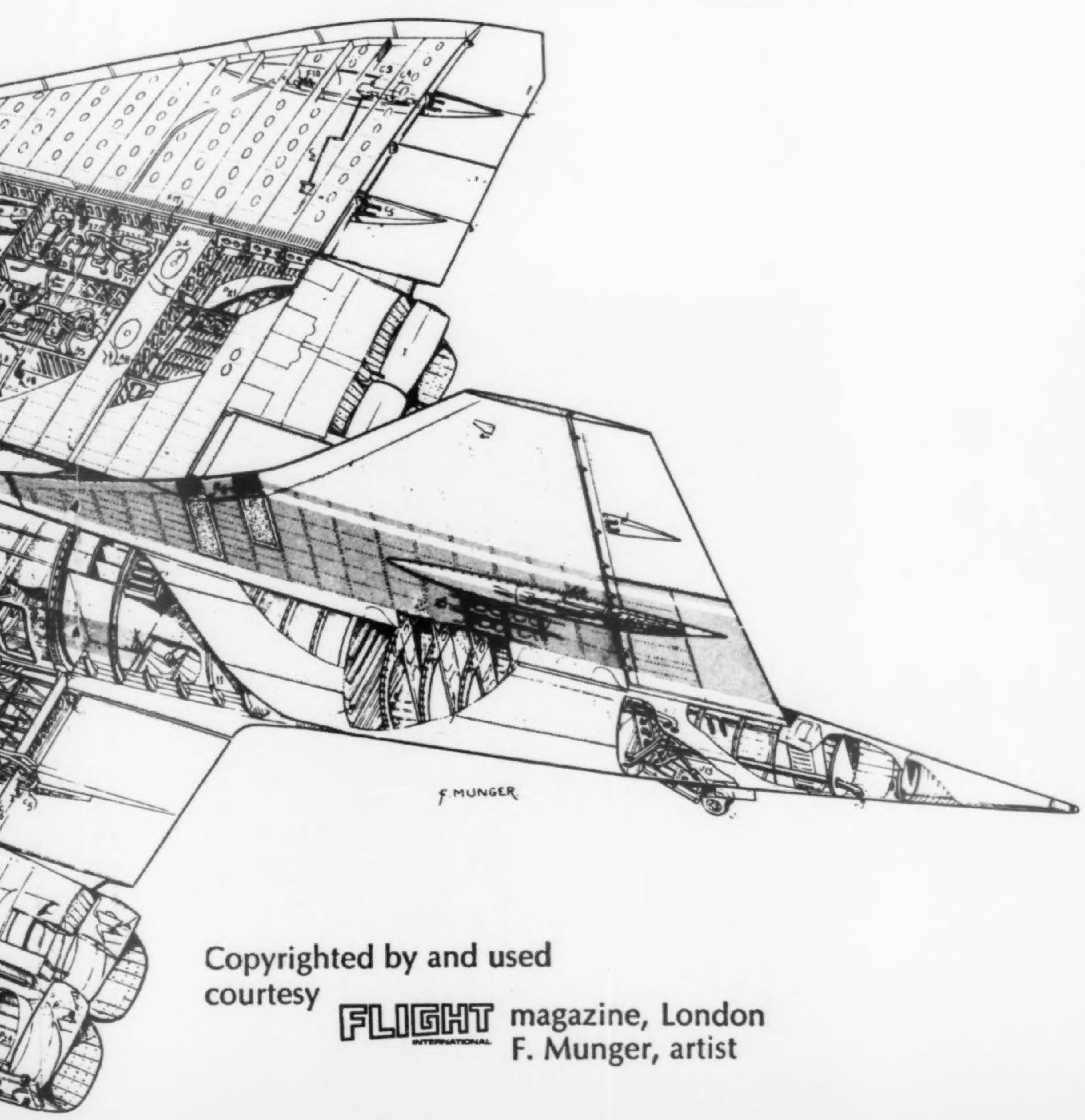
ailored for distinctive requirements and environments

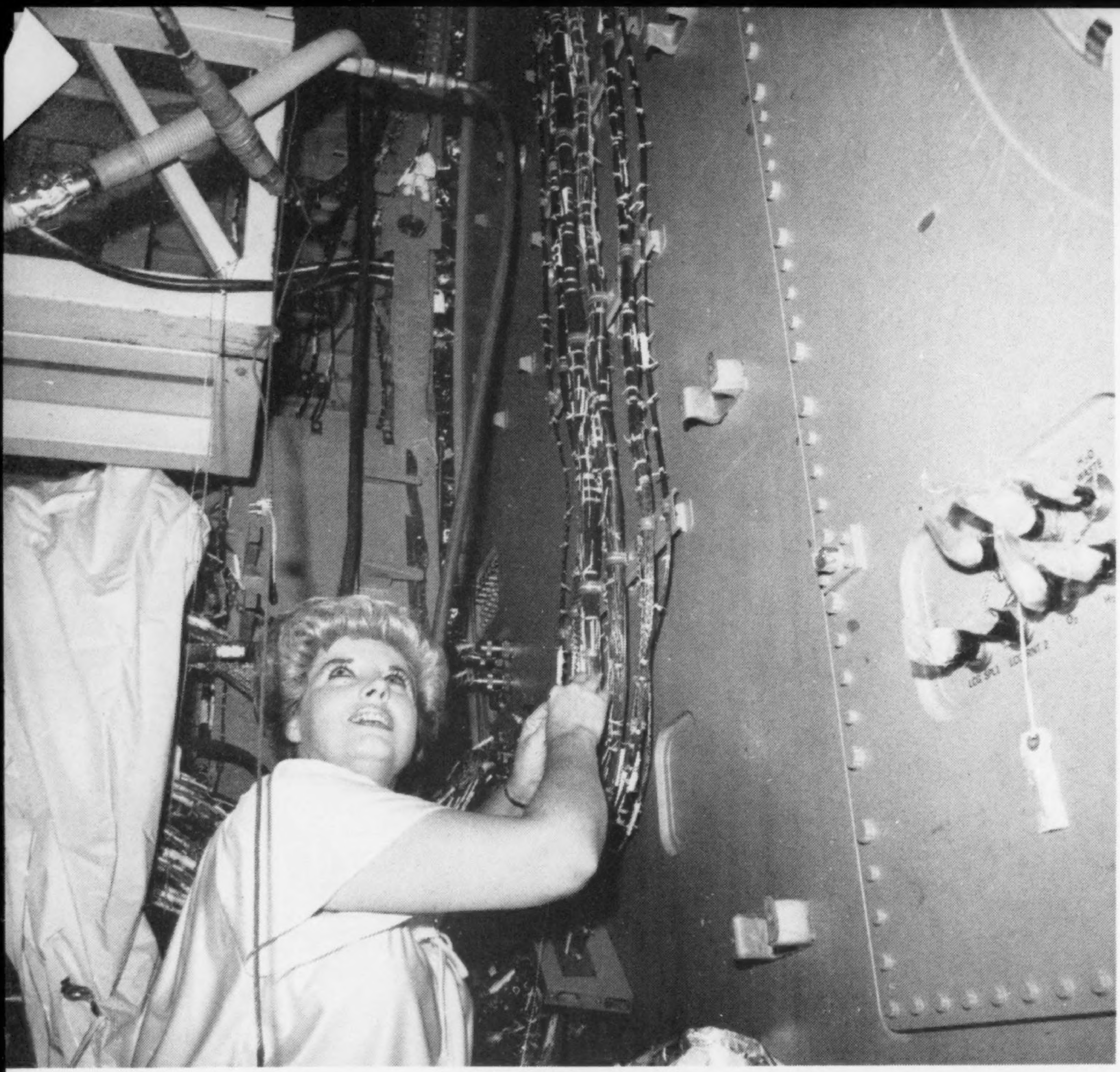


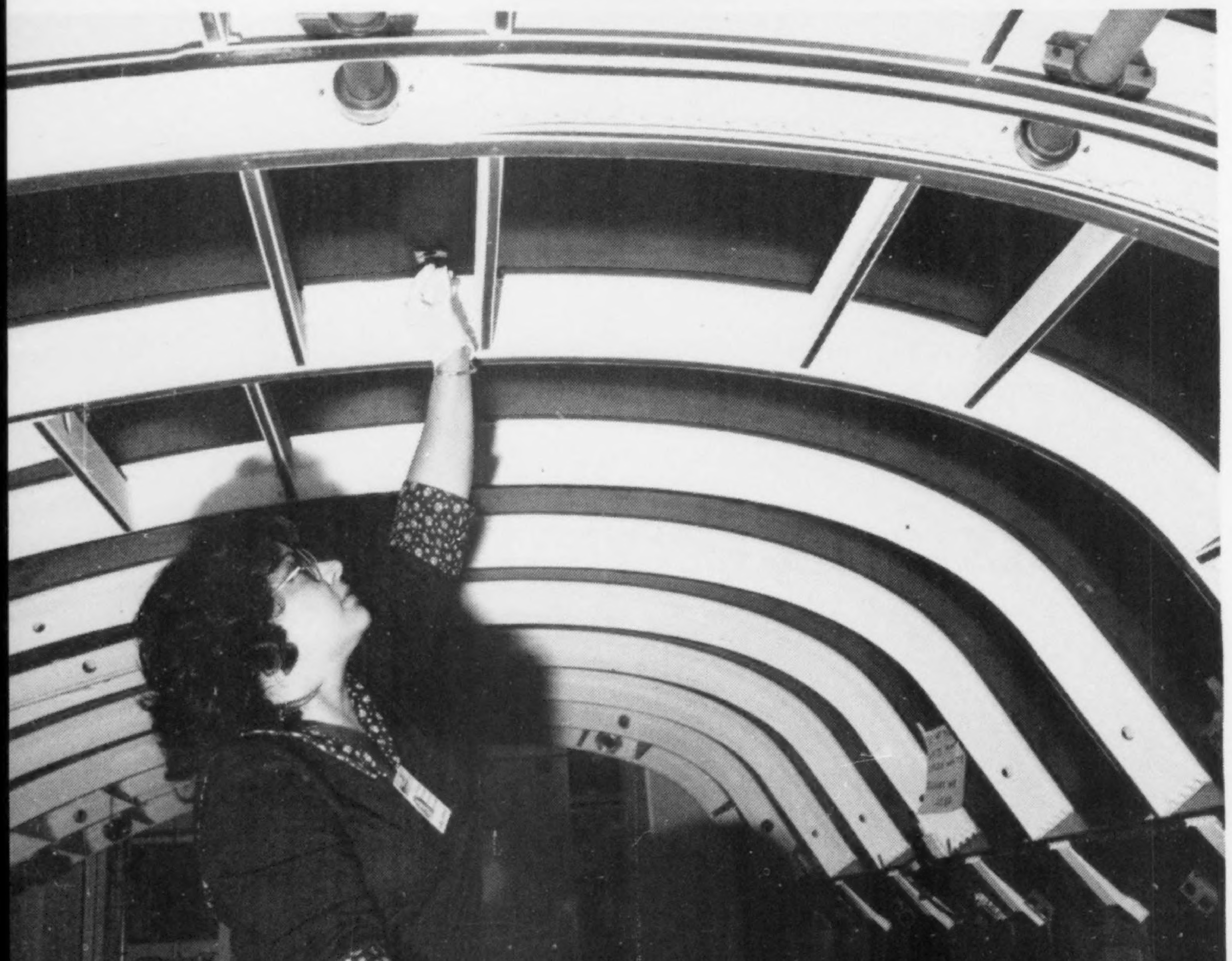
Copyrighted by and used courtesy FLIGHT INTERNATIONAL magazine, London
F. Munger, artist

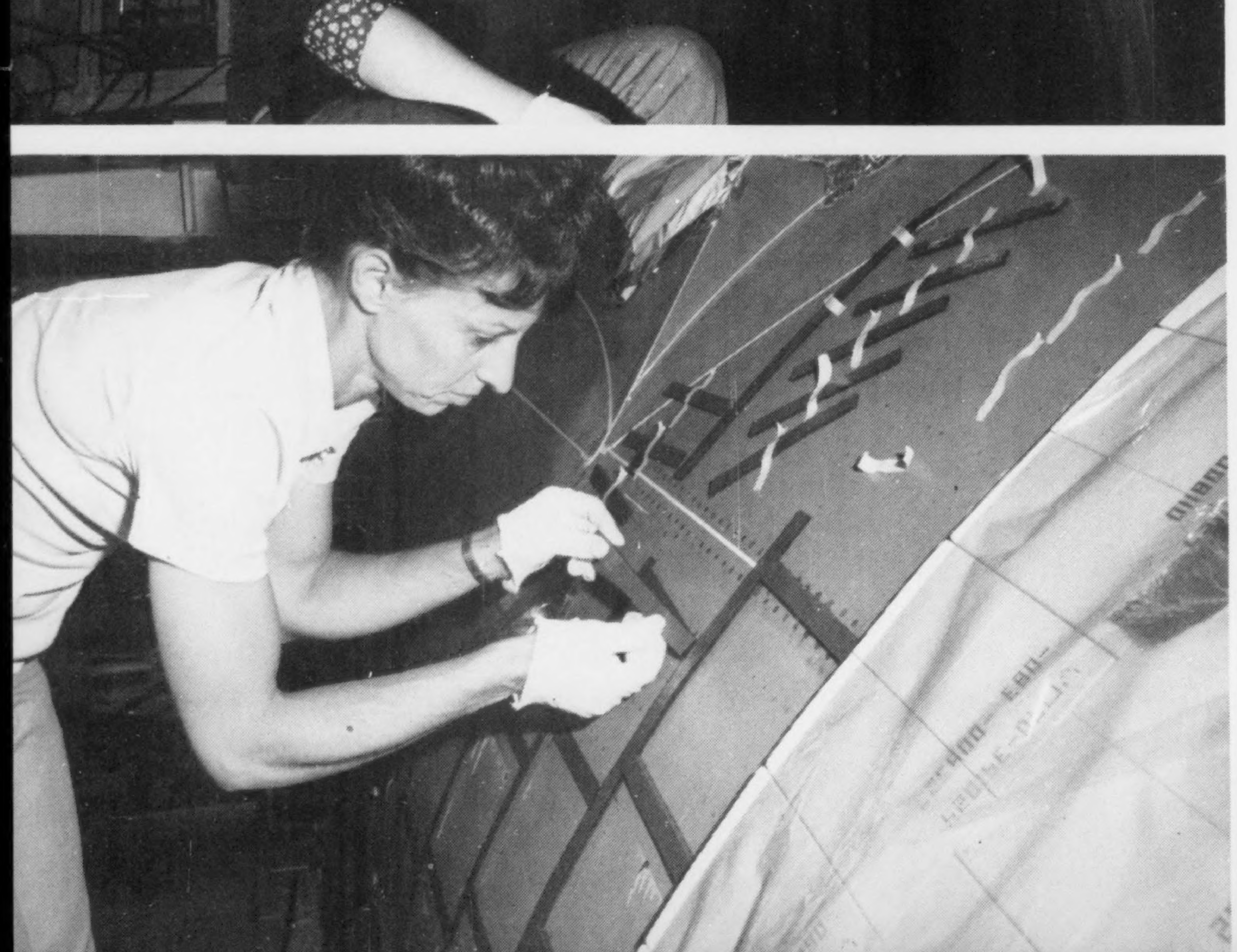
Aerodynamic heating is a major problem for designers of craft which are to fly faster than sound. Metals have their limits of endurance. As Richard Hallion explains, on Page 7, Concorde was deliberately designed for speeds under Mach 2 so that it could be built of the familiar aircraft material, aluminum. In supersonic cruising, the heat of the nose must never exceed 127°C (260°F); when the plane approaches that temperature, the crew slows it down.

The X-15s had to withstand brief surges of heating to 500°C. Frames were of stainless steel and titanium, which is stronger than steel at the same weight (and more expensive). Also, X-15s were covered with Inconel X, a nickel and steel alloy of great strength and heat resistance.

An orbiter's frame can be made of aluminum because the craft is completely covered with thermal protective materials for the few moments of peril during reentry (see Page 10). At that time, heat may reach 1200°C on the underside which slams into the atmosphere. New composites are also used to save weight, as graphite epoxy for the doors of the cargo bay. In the aft fuselage, the structure which must carry the thrust of the engines is made of boron-epoxy diffusion-bonded to titanium for extraordinary strength and heat resistance.







The Innards of Orbiter 102

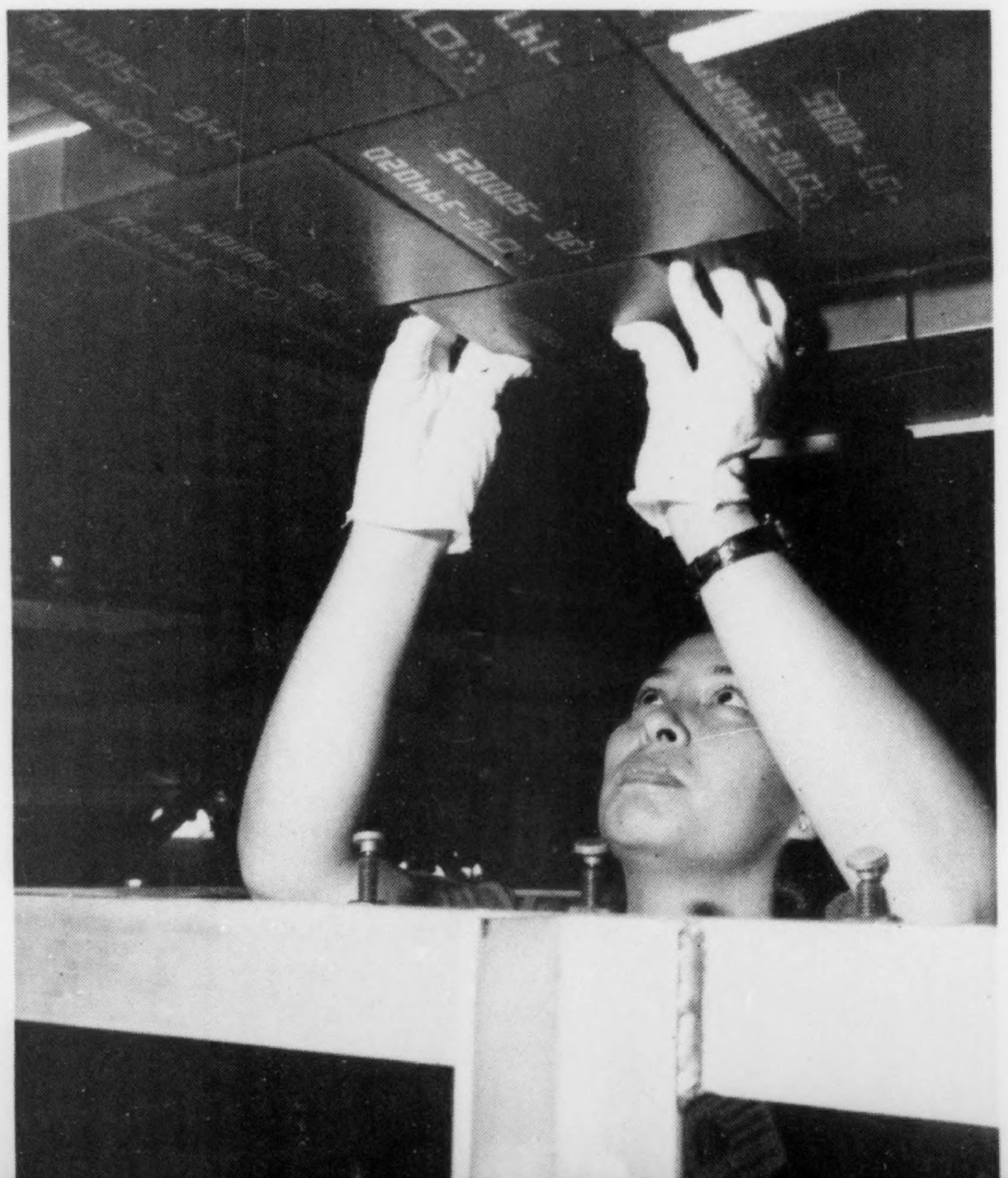
Only artists can illustrate the way Shuttle orbiters will work in space. But what is the vehicle actually like, close up? *Air & Space* asked the builder, Rockwell International, to photograph some of the people now putting together OV-102, which will be the first to orbit. Launch is presently set for late 1979. These scenes are in the Rockwell plant at Palmdale, California. The first orbiter, named "Enterprise," was also built here. Carried aloft by a 747 jet, it made short flights in the summer of 1977, and is now being used in tests simulating the stresses of launch.

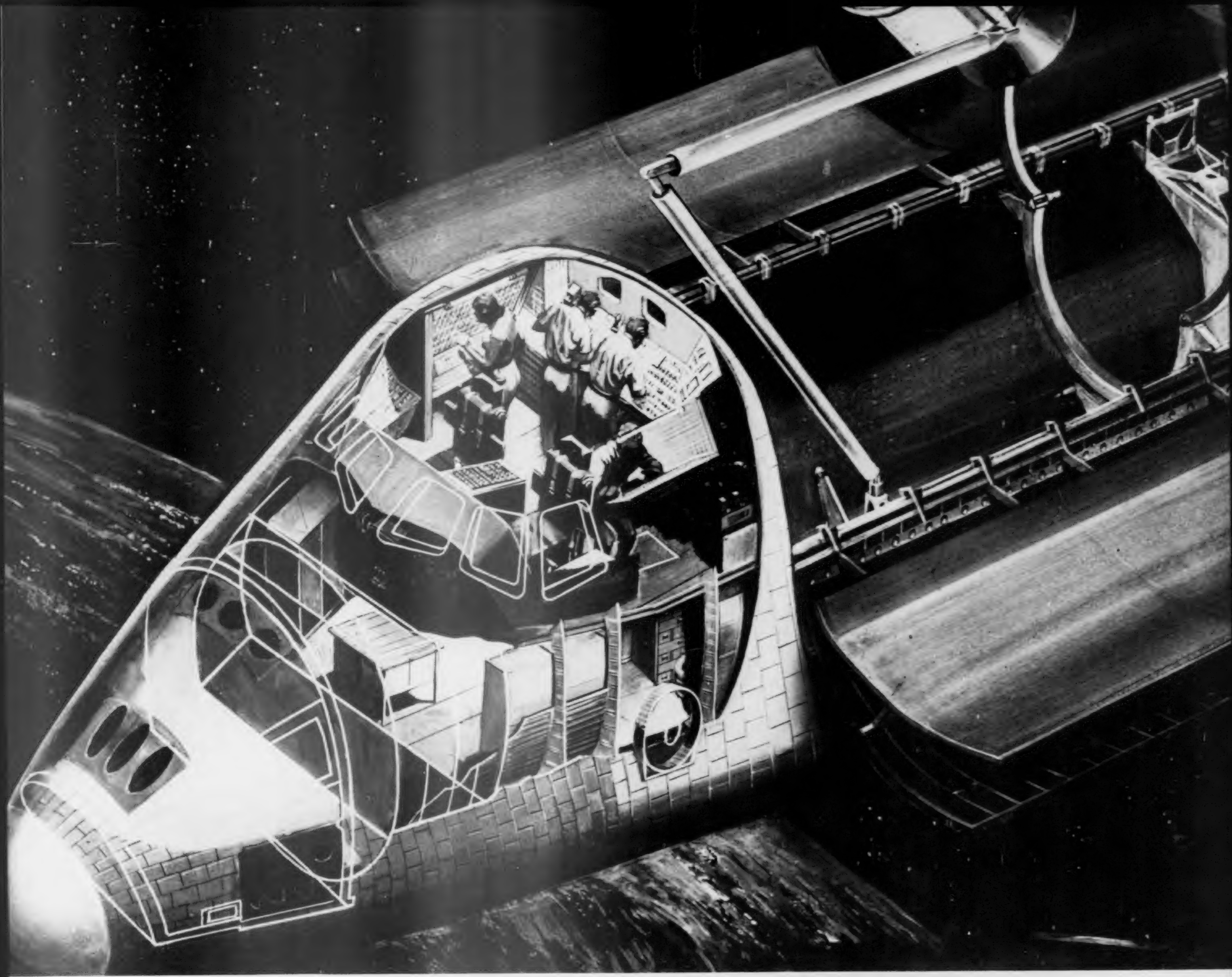
The "spaghetti" of wiring in these pictures hints at the complexity of controls for a craft which must work as a launch vehicle, a spacecraft, a scientific research laboratory, a space station for crew and scientists, and an aerodynamically viable glider for returns to Earth.

Top left: Forward bulkhead. The wall is the payload bay side of the aft flight deck where two of the crew are shown at work in the drawing, top of opposite page. Wiring goes to the aft fuselage as well as to operational elements in the payload bay. Studs outline the hatch which can be removed for installation of an airlock or the tunnel connection to Spacelab, a scientific laboratory being built by the European Space Agency to fit this bay.

Center left: One of the graphite epoxy payload bay doors mounted on a work structure. Woman is installing a strain gage for functional tests.

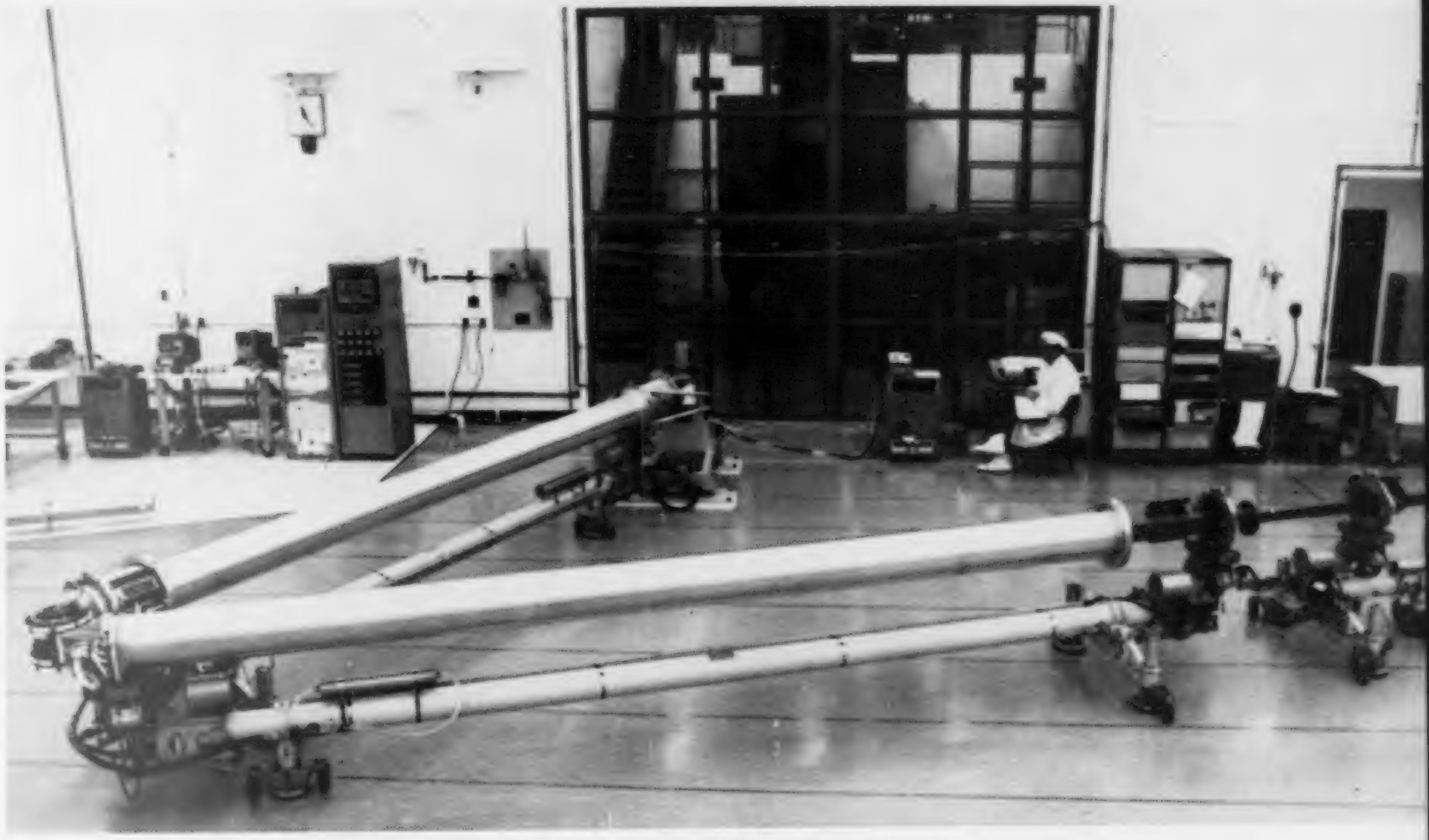
Bottom left and below: Putting on the outer "skin" of more than 30,000 silica tiles. These dissipate heat so rapidly and insulate so well that a person can hold one side even when the other side is red hot. First, adhesive-coated strips of Nomex (nylon) felt are laid down as a base for the tiles. The felt itself insulates to 371°C (700°F) in the cracks between tiles.





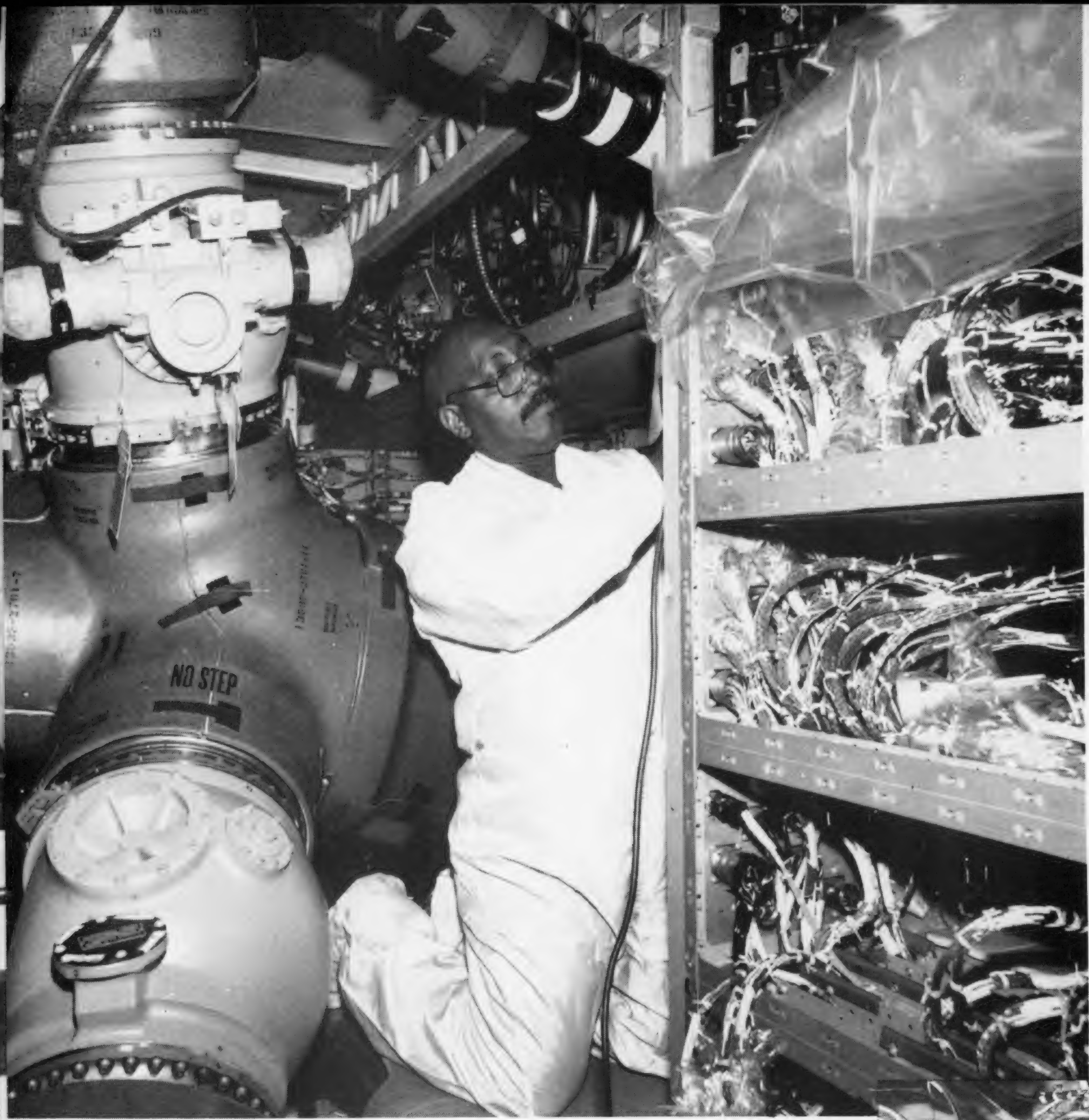
Above: The cutaway drawing shows the two levels of the cabin—downstairs, a living area; upstairs, the flight deck with flight controls forward and payload controls rear. Two windows overlook the cargo (payload) bay, 18.3 meters (60 ft) long and 4.6 meters in diameter. It is wide open when the doors swing outward in space. A crew member is manipulating the long arm (simplified sketch) to lift a satellite from its cradle and release it to space.

Right: Prototype of the actual arm is undergoing tests at Spar Aerospace, Ltd., Toronto, Canada. When straightened, the arm is 15.24 meters long, and can be mounted on either side of the cargo bay. The lower pipe is an air supply system used only for tests. On Earth, the arm can lift practically nothing, but in space it can wrestle with weightless payloads which down here would tilt the scales as much as 29,484 kilograms (65,000 lb.) The Canadian government underwrote the development of the system and is providing NASA the first arm; NASA will buy subsequent units.



For free Shuttle literature, write to NASA Johnson Space Center, Code JM-61, Houston, Texas 77058 (or to one's own regional NASA Center).

Inexpensive booklets to order: *Space Shuttle*, 89 pp., lavish color illus. and diagrams, NASA SP-407, 1976. Government Printing Office, Washington, DC 20402, Stock No. 033-000-00651-9, $2.50. Also: *Space Shuttle*, 8 pp., illus., NASA Facts NF-79/6-77, from Government Printing Office, Stock No. 003-000-00679-9, 60¢ (minimum order, $1.00).



The Innards of Orbiter 102

Continued

Left: Propulsion plumbing inside the aft fuselage. The 43.18 centimeter diameter pipe (17 in.) brings liquid hydrogen (LH_2) from the external tank and divides, here, to distribute the propellant partly to the three main engines, and partly to the LH_2 fill or drain disconnect mechanism of the tank. Similar pipes feed in liquid oxygen (LO_2) propellant. The shelves at the right are in avionics bay No. 5 on the rear payload bay bulkhead; the wiring is for flight control subsystems.

First below: Control cables and hydraulic lines inside the aft fuselage; these run to the "aft body flap," a horizontal panel under the three engine nozzles; the flap is movable for aerodynamic purposes during return to Earth.

At bottom below: A control subsystem in the forward fuselage near the nose of the orbiter. The engineer is making electrical tests and wears a headset for communications with the central checkout control room at the Rockwell International shop.

Below: Hydraulic lines inside a channel in the aft fuselage. These lines carry fluids which work like automobile brake fluid. The specialist is installing lines for flight control mechanisms with the help of a standoff tool.

NASA's Space Benefits Briefing Notebook (free) gives data students can use to study the ways in which NASA-developed aerospace technology is re-used to the advantage of earthly affairs.

SPINOFFS

NASA's research-and-development (R&D) efforts force the evolution of new technology. The agency makes pioneering advances for aviation and creates the program for space where many requirements are unlike any on Earth. Since the R&D is paid for by taxpayers (about one cent in each tax dollar), the results belong to the public. Further, the 1958 Space Act establishing NASA directed the new agency to "provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof." NASA's Technology Utilization Office works at this, but as Mr. Zisfein says in rhyme, Page 2, the process is not simple.

Seven Industrial Applications Centers around the country are linked to a master computer which has access to more than 10 million technological documents. NASA's are included. Anyone may search for information, paying a nominal charge for help. The staff includes scientists and engineers who can understand the technical talk of their clients, know how to get the most from the computer, and keep their transactions confidential.

Many smaller firms cannot afford R&D departments, but can draw on federal resources. They may become licensed to use certain material exclusively.

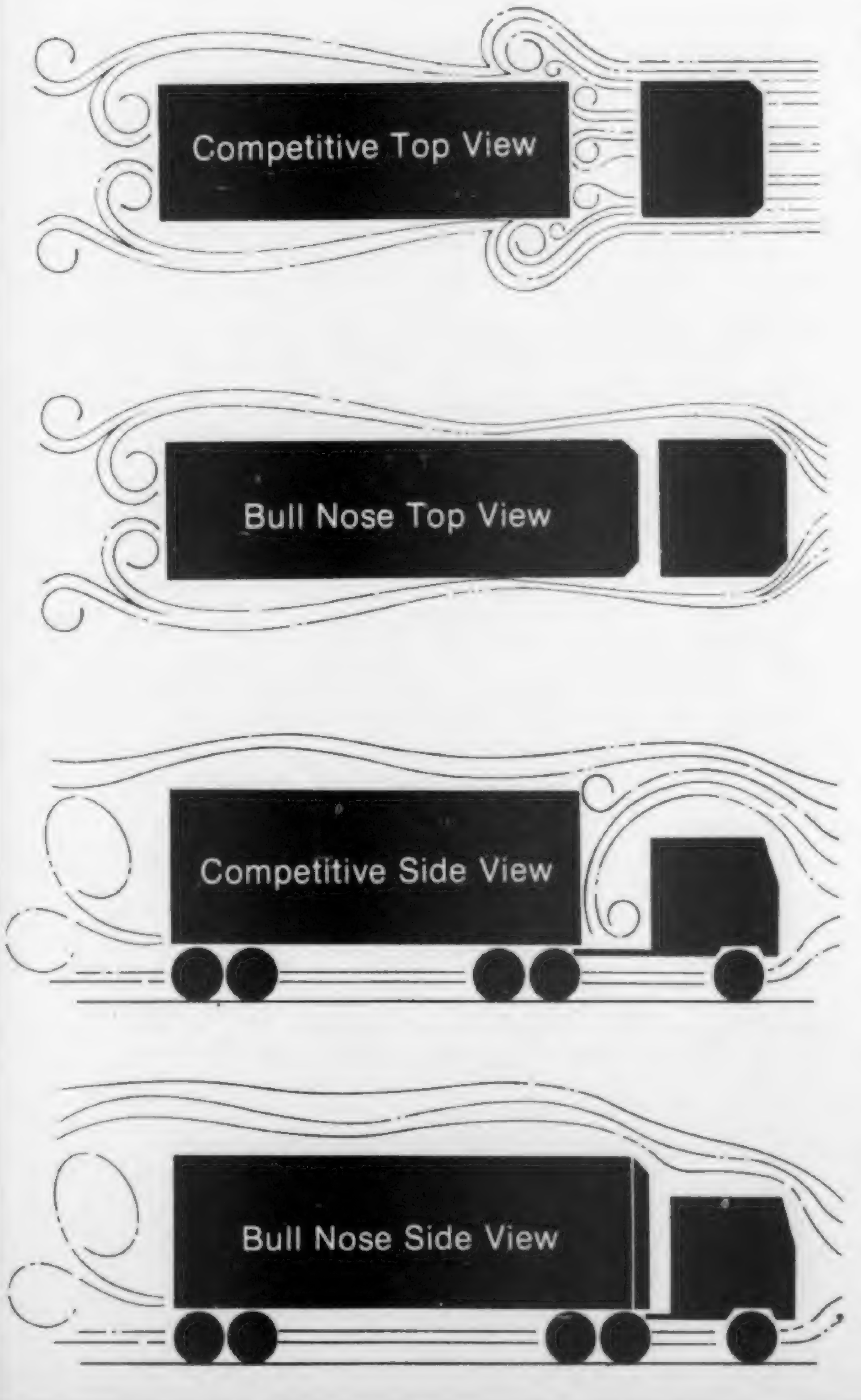
NASA's Tech Utilization office publishes information at three levels. The annual *Spinoff** is a glossy, colorful, popular story about the secondary uses of aerospace technology in ways and products which the public can readily understand. *Space Benefits*** is a plain, unillustrated handbook, updated annually by the Denver Research Institute, University of Denver. The 400 to 500 condensed entries note the most recent, known secondary uses of NASA's technology. Some companies adapt or adopt management systems, computer programs or other quality-improving methods which are not visible in the finished product. What makes this book useful to students is the thorough indexing, four ways—by topic, state, organization, and NASA Field Center. One can quickly identify local users and perhaps get a first-hand story. Items are grouped in 20 categories, each prefaced by discussion of one or more Key Issues; these could provide the framework for student papers in business or economics.

NASA also issues *Tech Briefs* of explicit details for engineers.

* *Spinoff 1978,* paperback, 8½ by 11 in., 124 pp., lavish color illus. Lists 26 offices around the country which channel NASA technology to other users. Government Printing Office, Washington, DC 20402, Stock No. 033-000-00712-4, $3.25. (*Spinoff 1979* available in April.)

** *Space Benefits, NASA Benefits Briefing Notebook,* paperback, 8 by 10 in., usually about 300 pp. From Director, Technology Utilization Office, P.O. Box 8757, Baltimore/Washington International Airport, Maryland 21240, free. (Also inquire here about Tech Briefs.)

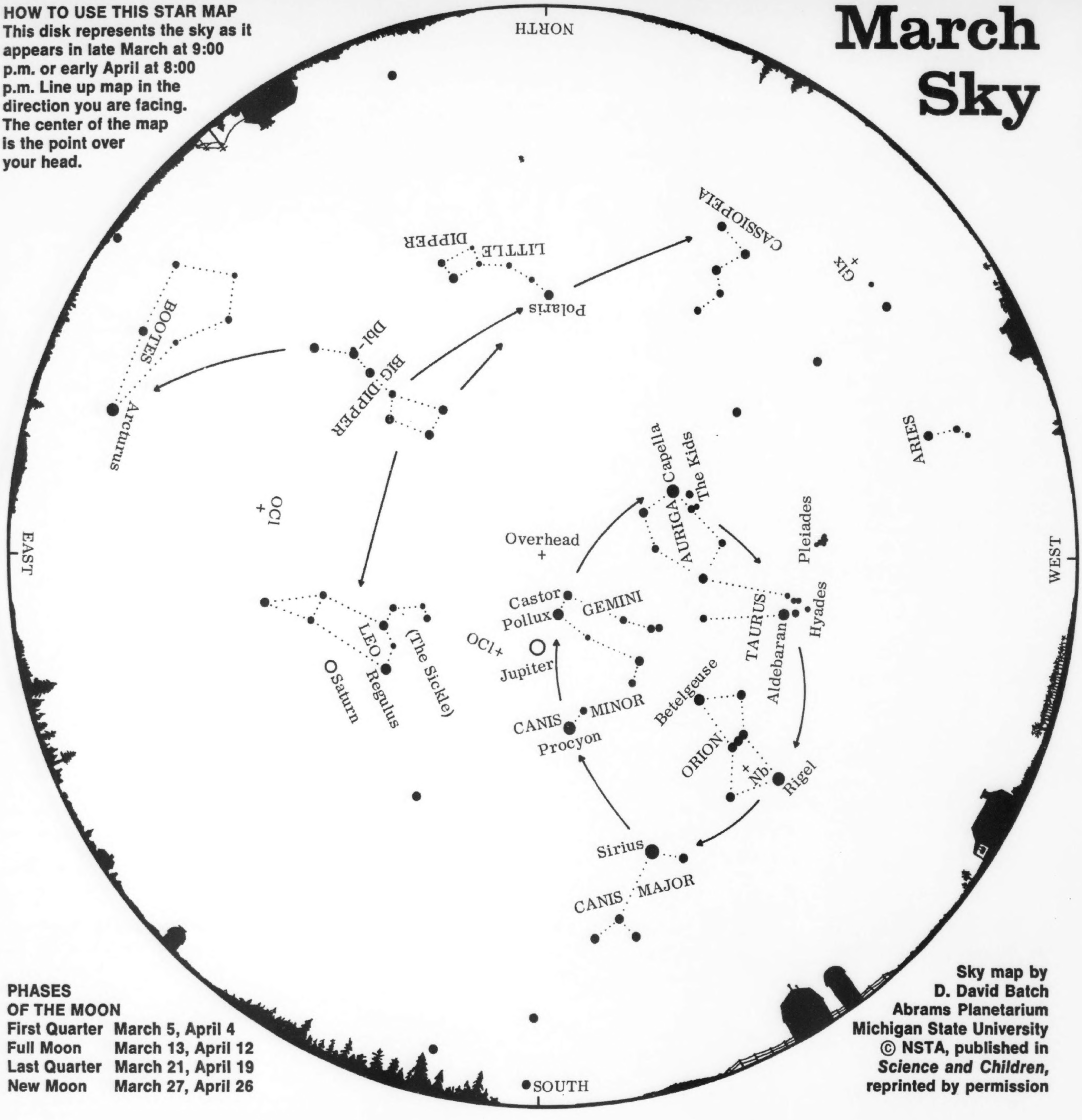
NASA Films, catalog revised periodically; about 30 pp., titles to borrow at no cost except return postage. From regional NASA Centers, or NASA Headquarters, Code LFB-9 (Publications), Washington, DC 20546, free. Several films cover spinoffs.



Left: The "Bull Nose" cattle transport is a new design based on NASA's aerodynamics research. Reduced space between cab and trailer eliminates air turbulence and drag; fuel savings are significant. Below: A machine saws ¼-inch wide by ¼-inch deep grooves across an airport runway. NASA showed that these rain-drains minimize hydroplaning skids by landing aircraft. Highways also are made safer; wet-highway accidents on grooved sections are sharply reduced.

March Sky

HOW TO USE THIS STAR MAP
This disk represents the sky as it appears in late March at 9:00 p.m. or early April at 8:00 p.m. Line up map in the direction you are facing. The center of the map is the point over your head.


NORTH
LITTLE DIPPER
CASSIOPEIA
Polaris
Glx
BOOTES
Arcturus
Dbl-
BIG DIPPER
OCl
EAST
ARIES
Capella
The Kids
AURIGA
Pleiades
Overhead
WEST
Castor
Pollux
GEMINI
OCl
Jupiter
TAURUS
Aldebaran
Hyades
LEO
Regulus
(The Sickle)
Saturn
CANIS MINOR
Procyon
Betelgeuse
ORION
Nb
Rigel
Sirius
CANIS MAJOR
SOUTH

PHASES OF THE MOON

First Quarter	**March 5, April 4**
Full Moon	**March 13, April 12**
Last Quarter	**March 21, April 19**
New Moon	**March 27, April 26**

Sky map by
D. David Batch
Abrams Planetarium
Michigan State University
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Science and Children,
reprinted by permission

by Dennis L. Mammana
Staff Astronomer
Flandrau Planetarium, Tucson, Arizona

Spring comes to the northern hemisphere at approximately 22 minutes past midnight on March 21, bringing weather which should be more conducive to evening stargazing. The splendid deep-sky objects of winter set early in the west as springtime stars rise in the east.

From our own cosmic backyard, two planets—Jupiter and Saturn—are plainly visible to the unaided eye during March and April evenings. Three rules-of-thumb help identify them: (1) Both planets are bright, Jupiter being brighter than Saturn; (2) planets are always seen among the constellations of the zodiac; (3) stars appear to twinkle more than planets do.

To find Jupiter this month, follow a straight line between the stars Castor and Pollux southward until the line intersects the bright planet. The Moon will appear just south of Jupiter on the evenings of March 9 and April 5.

It is fascinating to realize that two U.S. spacecraft are up there near Jupiter at this time, nearly 811 million kilometers away (532 million miles). After an 18-month trip, Voyager 1 made its closest approach (within 351,000 kilometers) on March 5, 1979. Voyager 2, on a slower trajectory, takes 22 months to reach Jupiter and will race by on July 9. Both provide scientific data and spectacular closeup photographs of the largest planet, 11 times greater in diameter than Earth, with 1,316 times the volume of Earth. Jupiter's gravitational mass, more than 300 times that of Earth, whips the spacecraft around behind, adding velocity. The Voyagers are then aimed for Saturn, and will reach the ringed planet in 1980 and 1981. If all goes well, again they will return pictures and data.

To find Saturn this month, locate the constellation Leo the Lion in the eastern sky. Saturn is in the lion's belly. The Moon will appear just south of Saturn on the evenngs of March 12 and April 8.

The Planets of the Sun—in Song

The words below, by NASM's Melvin Zisfein and Robert W. Wolfe, are sung to the tune of "The Farmer in the Dell" in the "For Space Juniors" section of NASM's "Exploring the Planets" Gallery.

The family of the Sun,
The family of the Sun,
Here are nine planets in
The family of the Sun.

Mercury is hot
And Mercury is small.
Mercury has no atmosphere;
It's just a rocky ball.

(Refrain to repeat as indicated:)

The family of the Sun,
The family of the Sun,
Here's another planet in
The family of the Sun.

Venus has thick clouds
That hide what is below.
The air is foul, the ground is hot.
It rotates very "slow."

(Repeat Refrain)

We love the Earth, our home,
Its oceans and its trees.
We eat its food; we breathe its air,
So no pollution, please.

(Repeat Refrain)

Mars is very red.
It's also dry and cold.
Some day you might visit Mars
If you are really bold.

(Repeat Refrain)

Great Jupiter is big.
We've studied it a lot.
We found that it has 14 moons
And a big red spot.

(Repeat Refrain)

Saturn has great rings.
We wondered what they were,
Now we know they're icy rocks
Which we saw as a blur.

The family of the Sun,
The family of the Sun,
Here are two more planets in
The family of the Sun.

Uranus and Neptune
We don't know much about.
Maybe you will study them
And then we'll all find out.

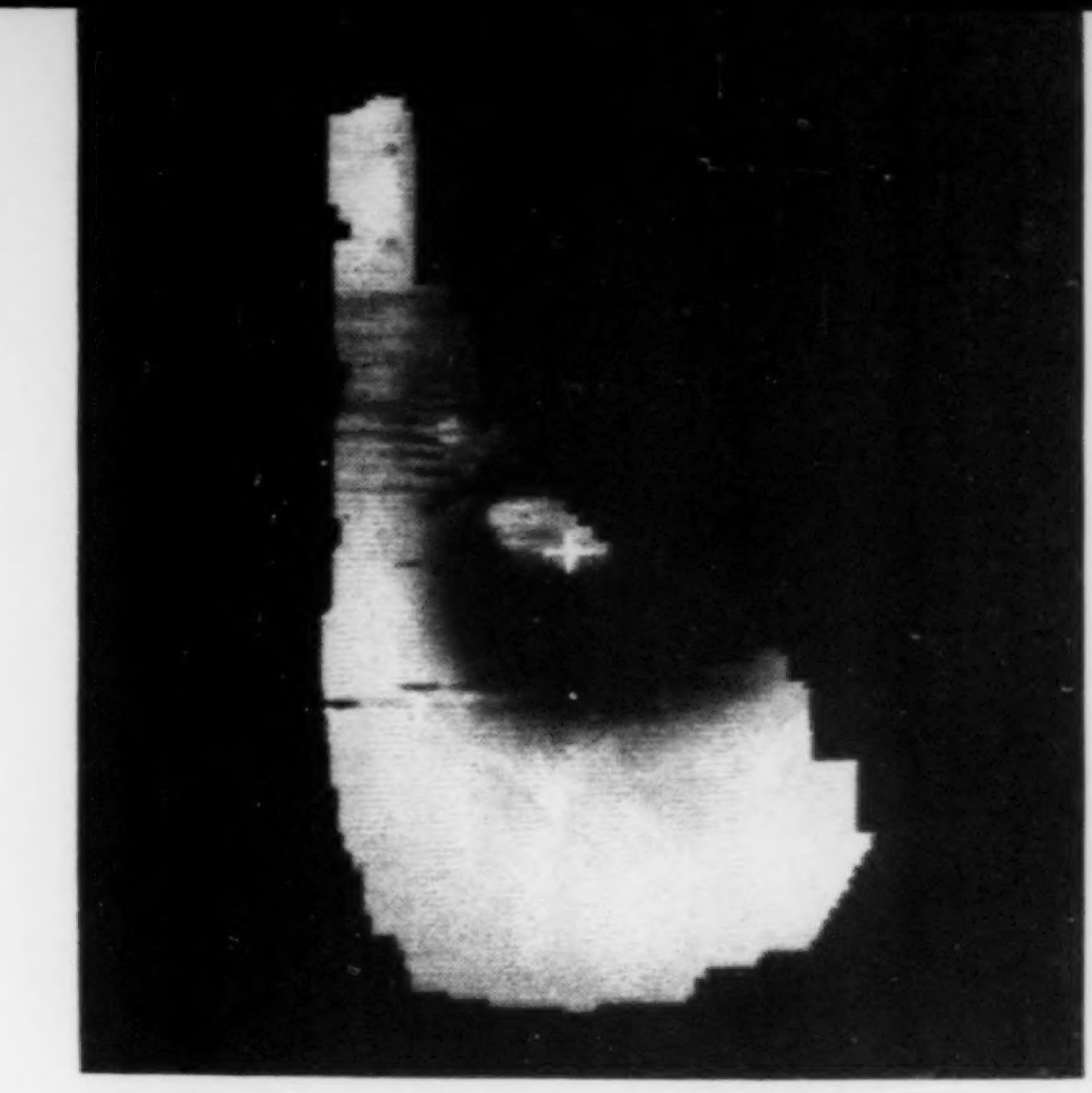
(Repeat Refrain)

Pluto's last in line.
It's farthest from the Sun.*
It's small and cold and icy too.
To land there won't be fun.

The family of the Sun,
The family of the Sun,
There are nine planets in
The family of the Sun.

---

* Every 248 years, Pluto's orbit (tilted 17° out of the ecliptic) brings it inside Neptune's for a period of 20 years. From 1979 to 1999, Neptune will be the farthest from the Sun.



What is it? Why, the northern hemisphere of Venus, of course, day and night sides around the North Pole (white cross). This is one of the first images returned by the Infrared Radiometer on the Pioneer spacecraft which arrived in early December. The instrument measures thermal emission from the atmosphere, the dark cloud around the Pole being —30°C, warmer than cloudtops over the equator.

A Call for Papers

NASM is inviting papers (or a detailed abstract) about multicultural programs in aerospace education, for a conference on the subject at NASM next June.

Accepted papers will be published in a summary report. Selected authors may present their stories personally, sponsored by NASM. Further information is available from conference coordinator Lonnie Bunch, Room 3601B (Museum address on back cover). Telephone: 202/381-4166. Papers should be received by March 26, 1979.

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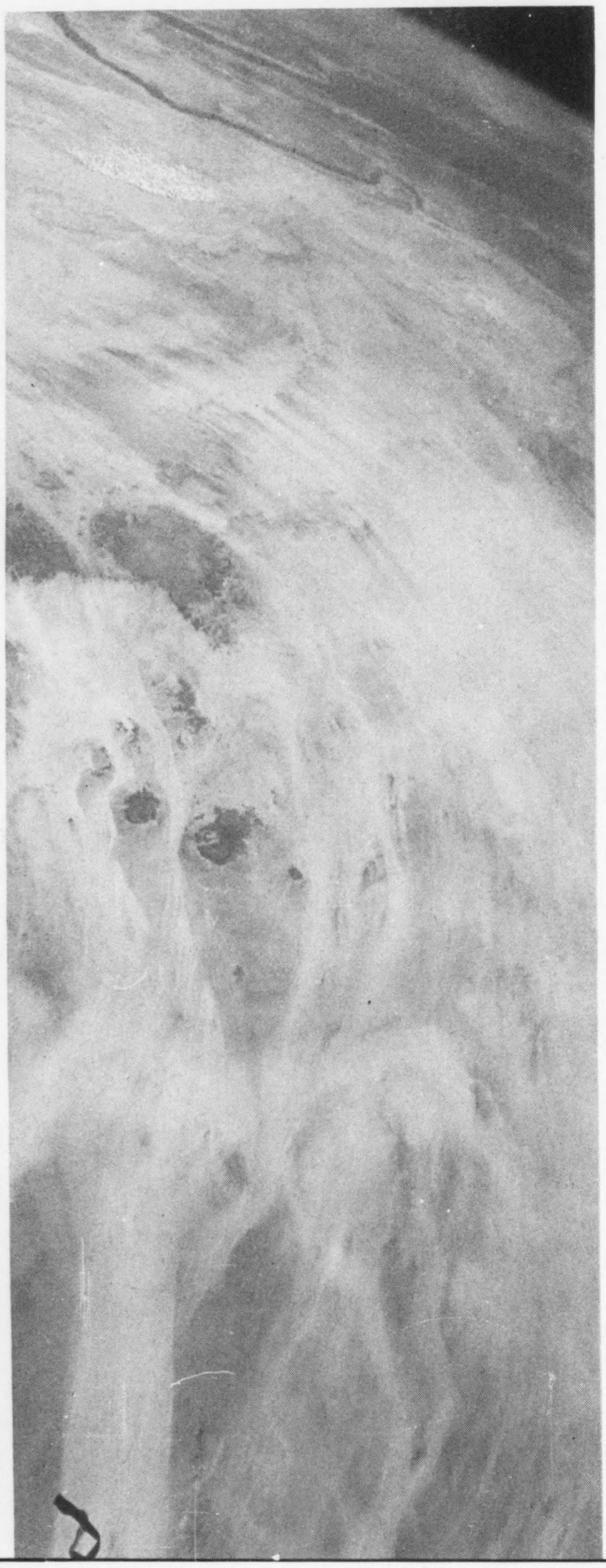
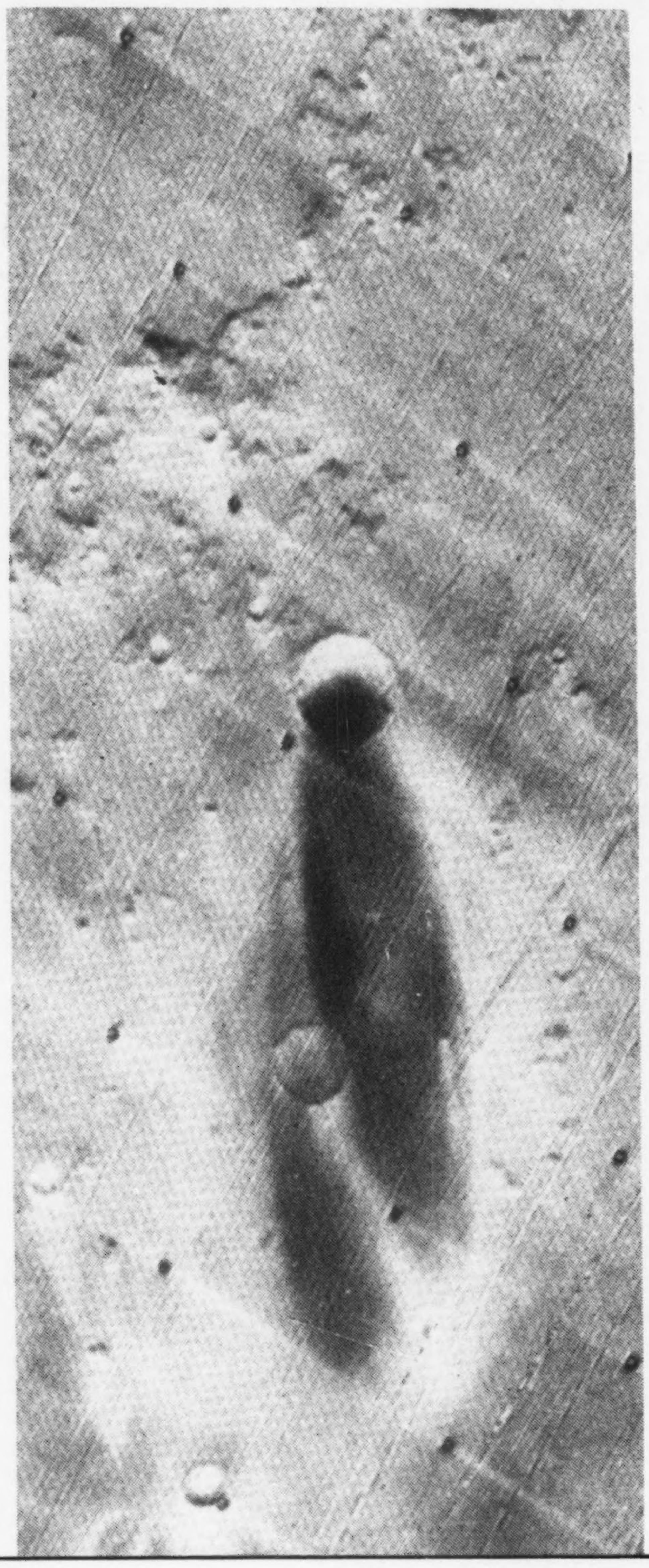
THINK ALONG WITH PLANETARY GEOLOGISTS



Air & Space, Mar.-Apr. 1979

Winds that scour the barren planet Mars, and winds over the deserts of Earth leave similar streaks behind obstacles. Here are satellite views of both planets. Which is Earth?

Clue: Shoreline and sea at the top, left.



by Andy Chaikin
Center for Earth
and Planetary Studies, NASM

Before the era of satellite photography and imagery, Earth's unexplored deserts were about as much of a mystery as the surface of Mars. Now intriguing similarities are showing up.

Far left is a photograph by astronauts aboard Gemini 11, 1966, showing two circular mountains in southwestern Egypt, an area with surface features that are similar to those on Mars. The larger mountain, called Jebel Uweinat, is about 50 kilometers in diameter. Both mountains have dark tails similar in appearance to the ones on Mars (near left). Last fall, a 1,000-mile exploration of Egypt's Western Desert was led by Dr. Farouk El-Baz, Research Director of NASM's Center for Earth and Planetary Studies, and science adviser to President Sadat of Egypt. His findings suggest that the Uweinat streak is made of dark materials eroded from the mountain and deposited in the "wind shadow" behind it.

The Mars image of the Memnonia region was taken from orbit by the Mariner 9 spacecraft in 1972. It shows a pair of craters (the larger one 25 km in diameter) which have dark tails or "wind streaks." These and other wind streaks on Mars are probably formed by deposition or erosion of material behind crater rims by the everpresent and often strong wind. Did a similar process produce the streaks on both planets? Detailed comparisons underway at NASM hopefully will give clues to the origin of both the Martian and the Egyptian features.

One way to simulate wind streaks at school is to blow superfine sugar over a model crater inside a long box used as a wind tunnel.

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